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WAR DEPARTMENT :: OFFICE OF THE SURGEON GENERAL

BULLETIN No. 6

AUGUST, 1914

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THE PROPHYLAXIS OF MALARIA WITH SPECIAL REFERENCE TO THE MILITARY SERVICE

BY

CHARLES F. CRAIG
Captain, Medical Corps, U. S. Army

UNITED STATES ARMY MEDICAL DEPARTMENT.

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LIST OF BULLETINS.

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No. 2. Papers by Officers of the Medical Corps, U. S. Army, read before the Fifteenth International Congress of Hygiene and Demography. January, 1913.

No. 3. Studies of Syphilis, by Charles F. Craig, Captain, Medical Corps, U. S. Army, and Henry J. Nichols, Captain, Medical Corps, U. S. Army, with Introduction by Major Frederick F. Russell, Medical Corps, U. S. Army. June, 1913.

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PUBLISHED BY AUTHORITY OF THE ACT OF CONGRESS APPROVED AUGUST 1, 1914, AND WITH THE APPROVAL OF THE SECRETARY OF WAR, FOR THE INFORMATION OF MEDICAL OFFICERS

UNITED STATES ARMY MEDICAL DEPARTMENT.

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PREFACE.

In the sundry civil act for 1914, under the appropriation for printing and binding for the War Department, it was provided:

> That the sum of $3,000, or so much thereof as may be necessary, may be used for the publication from time to time of bulletins prepared under the direction of the Surgeon General of the Army, for the information of medical officers, when approved by the Secretary of War.

Similar provision was made in the sundry civil act for 1915, and it is hoped that this appropriation will be continued from year to year in the future. It is intended that these bulletins shall be used for the publication to the Medical Corps of the special technical work of the service laboratories, the reports of the boards for the study of tropical diseases, and other work of medical officers which is of too special or technical a character to make it acceptable for publication in the medical journals and the Military Surgeon.

The bulletin will be published, if possible, at least quarterly. Officers of the corps are requested to submit suitable articles to this office for use in the bulletin, with the understanding that they may be published elsewhere by the author if found not suitable for the bulletin.

William C. Gorgas,
Surgeon General, United States Army.

September 24, 1913.

ORDER.

A board of officers of the Medical Corps, representing the Sanitary and Statistical Division and the Library of the Surgeon General's Office and the Laboratory of the Army Medical School, is hereby convened for the purpose of collecting materials and arranging for the publication of the bulletins for the instruction of medical officers authorized by the act approved June 23, 1913.

Detail for the board:

Lieut. Col. Champe C. McCulloch, jr.
Maj. William J. L. Lyster.
Maj. Eugene R. Whitmore.

By order of the Surgeon General:

Chas. M. Gandy,
Lieutenant Colonel, Medical Corps, United States Army.

TABLE OF CONTENTS.

Page.

Introductory Remarks.... 9
Illustrations of successful malaria prophylaxis.... 10
Results in the Army.... 10
Chapter I. The malaria plasmodia.... 17
Methods of demonstrating the plasmodia.... 17
Apparatus.... 17
Living specimens.... 17
Stained specimens.... 18
Method of staining.... 18
Staining reactions.... 20
Ross thick film method.... 20
Morphology and life cycle.... 21
Classification.... 21
Plasmodium vivax.... 22
Unstained specimens.... 22
Stained specimens.... 23
Plasmodium malariæ.... 24
Unstained specimens.... 24
Stained specimens.... 25
Plasmodium falciparum.... 26
Unstained specimens.... 26
Stained specimens.... 27
Plasmodium falciparum quotidianum.... 27
Living specimens.... 27
Stained specimens.... 28
Development of plasmodia in the mosquito.... 28
Morphology of the sexual forms of the plasmodia.... 30
Gametes of Plasmodium vivax.... 31
Gametes of Plasmodium malariæ.... 34
Gametes of æstivo-autumnal plasmodia.... 34
Differential diagnosis of the malarial plasmodia.... 36
Objects which may be mistaken for the plasmodia.... 37
In fresh blood.... 38
In stained preparations.... 39
Chapter II. The malaria mosquitoes.... 41
Geographical distribution.... 41
Number of infected mosquitoes.... 42
Species of mosquito in relation to malaria.... 43
Classification.... 42
External anatomy.... 44
Internal anatomy.... 45
Life cycle of anophelines.... 46
The ova.... 46
The larvæ.... 47
The pupæ.... 48
The adult mosquito.... 48

Chapter II. The malaria mosquitoes—Continued.
  Habits 48
    Of the larvæ 48
    Of adults 48
  Feeding 48
  Time of day of biting 49
  Flying distance 50
  Breeding places 51
  Color in relation to anophelines 52
  Longevity and hibernation 52
  Number of generations 53
  Resting position of adults 53
  Practical points in the differentiation of the anophelinæ 54
  Methods of collecting and dissecting mosquitoes 55
  Dissection of the salivary glands 56
  Dissection of the "stomach" 57
Chapter III. Prophylactic methods based upon the destruction of malaria mosquitoes 58
  General remarks 58
  Drainage 59
  The blind drain 59
  The cement-lined open drain 60
  Subsoil drainage with tiles 60
  Filling 60
  Removal of shelter 60
  Larvicides 61
  Kerosene (fuel oil) 61
  Canal Zone larvicide 63
  Other larvicides 64
  Destruction of larvæ by fish 64
  Abolition of breeding places about barracks and quarters 65
  Destruction of the adult mosquito 67
  Sulphur dioxide 67
  Smudges 68
  Pyrethrum powder 68
  Other fumigants 68
  Mosquito catching as a prophylactic method 68
Chapter IV. Prophylactic methods based upon the protection of man from the bites of mosquitoes 72
  General remarks 72
  Screening 72
  Selection of screening material 73
  Size of the mesh 73
  Method of screening 75
  Mosquito nets 75
  Head nets and gloves 7
  Use of odorous substances on the skin 7
  Results of screening 7
  Screening of malarial patients 7
Chapter V. Prophylactic methods based upon the destruction of malaria plasmodia (quinine prophylaxis) 8
  General remarks 8
  Action of quinine upon the plasmodia 8
  Form of quinine to be used in prophylaxis 8

Chapter V.—Prophylactic methods, etc.—Continued.
Methods of administration and dosage.......... 86
Celli's method.......... 86
Sergent's method.......... 86
Zieman and Nocht's method.......... 86
Plehn's method.......... 86
Koch's method.......... 86
Service method.......... 86
Quinine-fast strains of plasmodia.......... 87
Treatment of infections and "carriers".......... 88
Discovery and treatment of latent infections.......... 89
Proportion of latent infections.......... 90
Methods of diagnosing latent infections.......... 94
Treatment of latent infections.......... 94
Discovery of gamete carriers.......... 96
Time of occurrence of gametes.......... 97
Percentage of individuals showing gametes.......... 97
Estimation of number of gametes in prophylaxis.......... 98
Effect of quinine upon gametes.......... 99
Treatment of gamete carriers in prophylaxis.......... 99
Treatment of initial and recurrent infections in prophylaxis.......... 100
Results of quinine prophylaxis.......... 103
Chapter VI. The application of the methods of malarial prophylaxis to the military service.......... 107
General remarks.......... 107
Malaria prophylaxis in the field.......... 107
Malaria prophylaxis in semipermanent camps.......... 108
Malaria prophylaxis in permanent posts.......... 109
References.......... 113

THE PROPHYLAXIS OF MALARIA.

INTRODUCTORY REMARKS.

The discovery by Laveran of the parasites concerned in the etiology of the malarial fevers, and by Ross of the method of transmission of these parasites from man to man by the mosquito, has placed the prophylaxis of these infections upon a firm scientific basis; while the discovery of cinchona and its alkaloid, quinine, placed in our hands a true specific against the parasites. In many countries these discoveries have been taken advantage of in extensive campaigns against malaria, and such campaigns have been successful in proportion to the thoroughness with which measures based upon etiological facts have been applied in prophylaxis.

In this bulletin, prepared at the request of the editorial board appointed by the Surgeon General of the Army, special stress will be laid upon those measures that are most applicable in the prophylaxis of malaria in the military service, including service in the field as well as in semipermanent camps and permanent posts. It is obvious that methods of prophylaxis that would be suitable in a permanent post might be impracticable upon the march, in bivouac, and in camps lasting only a day or two, so that it will be necessary to consider somewhat *in extenso* the prophylactic measures suitable under the special conditions brought about by military operations as well as those suited to preventing infection in permanent posts.

At the present time our knowledge of the etiology of malarial infections is so extensive and accurate that no matter how badly a region may be infected or how difficult the local conditions may make the application of prophylactic measures some method may be adopted that will result in success. It is now proven beyond controversy that the malarial fevers are transmitted from man to man by mosquitoes belonging to the *Anophelinæ;* that these mosquitoes in order to become infective must have bitten an infected individual; that the malaria parasites undergo a definite cycle of development in both man and the mosquito, which, if interrupted at any stage, will result in the death of the parasites; and that these parasites, so far as we know, exist only in man and mosquitoes, so that it is unnecessary to consider other animal or insect hosts in the prophylaxis of malaria. Therefore it follows that if it were possible to destroy all malaria-carrying mosquitoes or kill all the plasmodia in the blood of all infected individuals we would succeed in the eradication of these fevers in every locality. Unfortunately, we must admit that in practice we can only hope for a partial success if we depend upon one method of prophylaxis alone, and it is generally necessary to combine methods looking to the destruction of mosquitoes, the protection of man from the bites of these insects, and the destruction of the malaria plasmodia.

That methods based upon the discoveries of Laveran and Ross, when properly applied, are successful has been proven by numerous sanitarians. The success achieved by Gen. Gorgas and Col. Kean, of the Medical Corps, in Habana; of Gen. Gorgas in the Canal Zone; of Celli in Italy; of Watson in the Federated Malay States; and of the Sergents in Algeria in the prevention of malaria has demonstrated for all time the wonderful value of prophylactic measures against these infections, and there is no more striking illustration of what may be expected from intelligent prophylaxis than is shown in Chart No. I, giving the malarial rates in the Canal Zone since 1906 to 1913. As will be noted, during 1906 nearly 7 per cent of the entire working force on the canal entered hospital each month suffering from malarial infections, while in 1912 less than 1 per cent per month entered hospital from these infections.

In the Army there has been a gradual and continued reduction in the number of cases of malaria since 1898, as shown by Chart No. II. It should be understood, however, that the enormous number of admissions from malarial fevers in 1898, 1899, and even in 1900, as shown in this chart, can not be taken as representing the actual facts, for it is well known that a very large percentage of the cases of typhoid fever occurring during these years, and especially during 1898 and 1899, were diagnosed as remittent malarial fever and so entered upon the records. However, if we accept the year 1901 as representing accurate statistics of this disease, it will be noted that the admission rate for all American troops, serving both at home and in our tropical possessions, has been reduced from 365.39 per 1,000, the rate for 1901, to 24.75 per 1,000, the rate for 1913.

The noneffective rate from malarial infections, the best index we possess of the influence of the disease upon the efficiency of the Army, has likewise fallen greatly. This rate for all American troops, as shown in Chart III, serving both at home and abroad, was 4.46 in 1903, while in 1913 it was only 0.53, the lowest noneffective rate from these fevers since 1898.

In the troops serving in the United States the reduction in malaria, as would be expected, has been more marked than in the Philippines. In Chart No. IV is given the admission and noneffective rates for these fevers since 1904, and it will be noted that there has been a steady decrease in both rates, until in 1913 we

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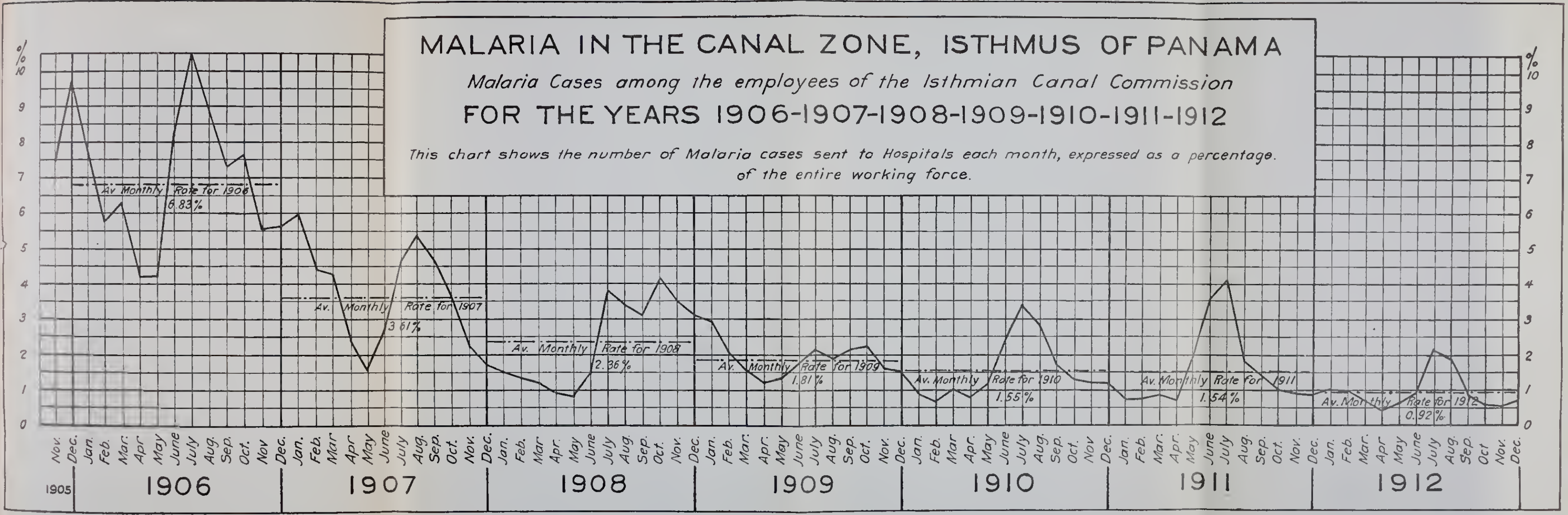
Chart No. 1.



MALARIA IN THE CANAL ZONE, ISTHMUS OF PANAMA

Malaria Cases among the employees of the Isthmian Canal Commission

FOR THE YEARS 1906-1907-1908-1909-1910-1911-1912

This chart shows the number of Malaria cases sent to Hospitals each month, expressed as a percentage of the entire working force.

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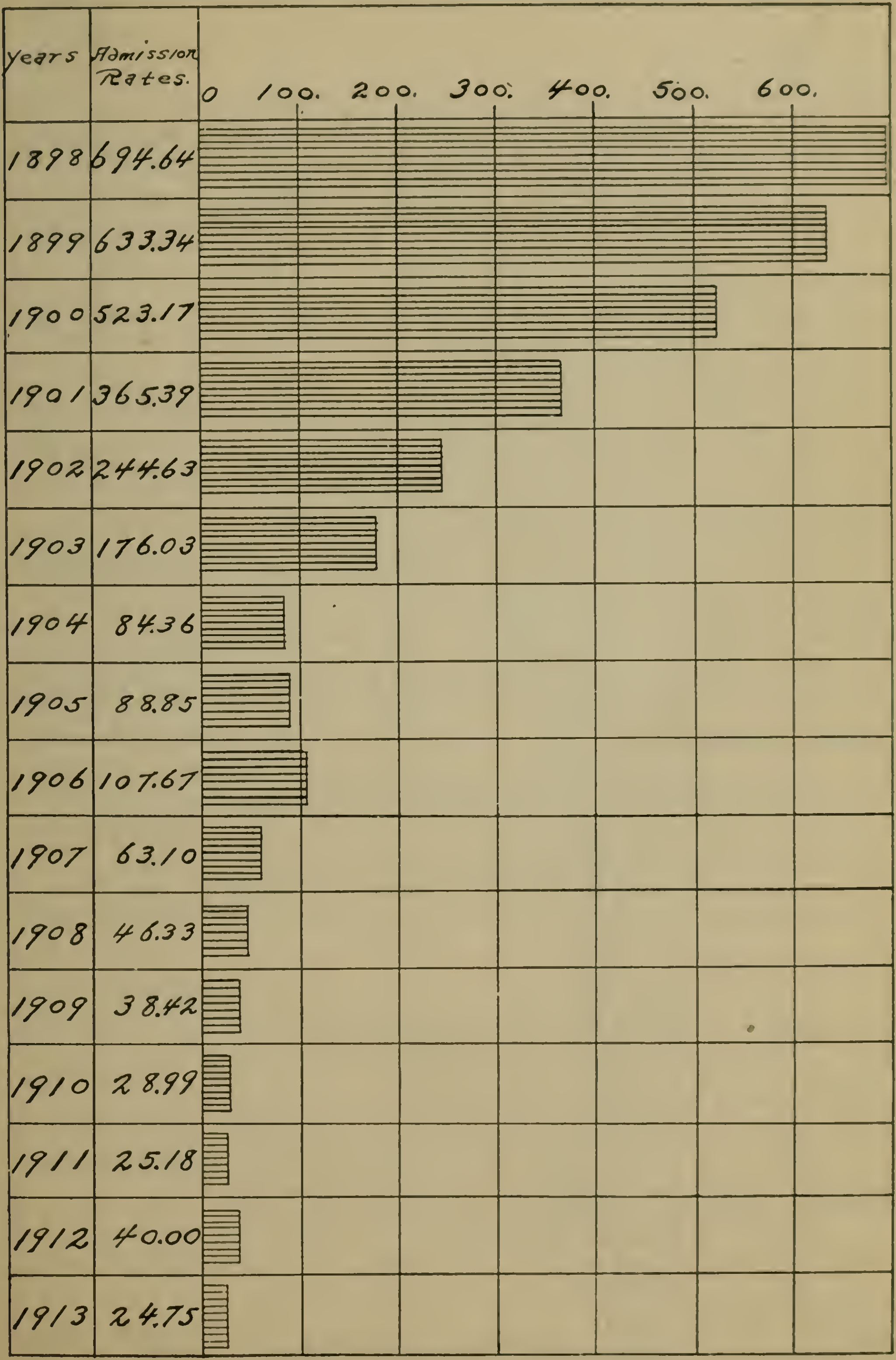
CHART NO. II.

Malarial Fevers.
Admission Rates.
Admission rates for Malarial Fevers, the Army, American troops {enlisted men} years, 1898-1913.

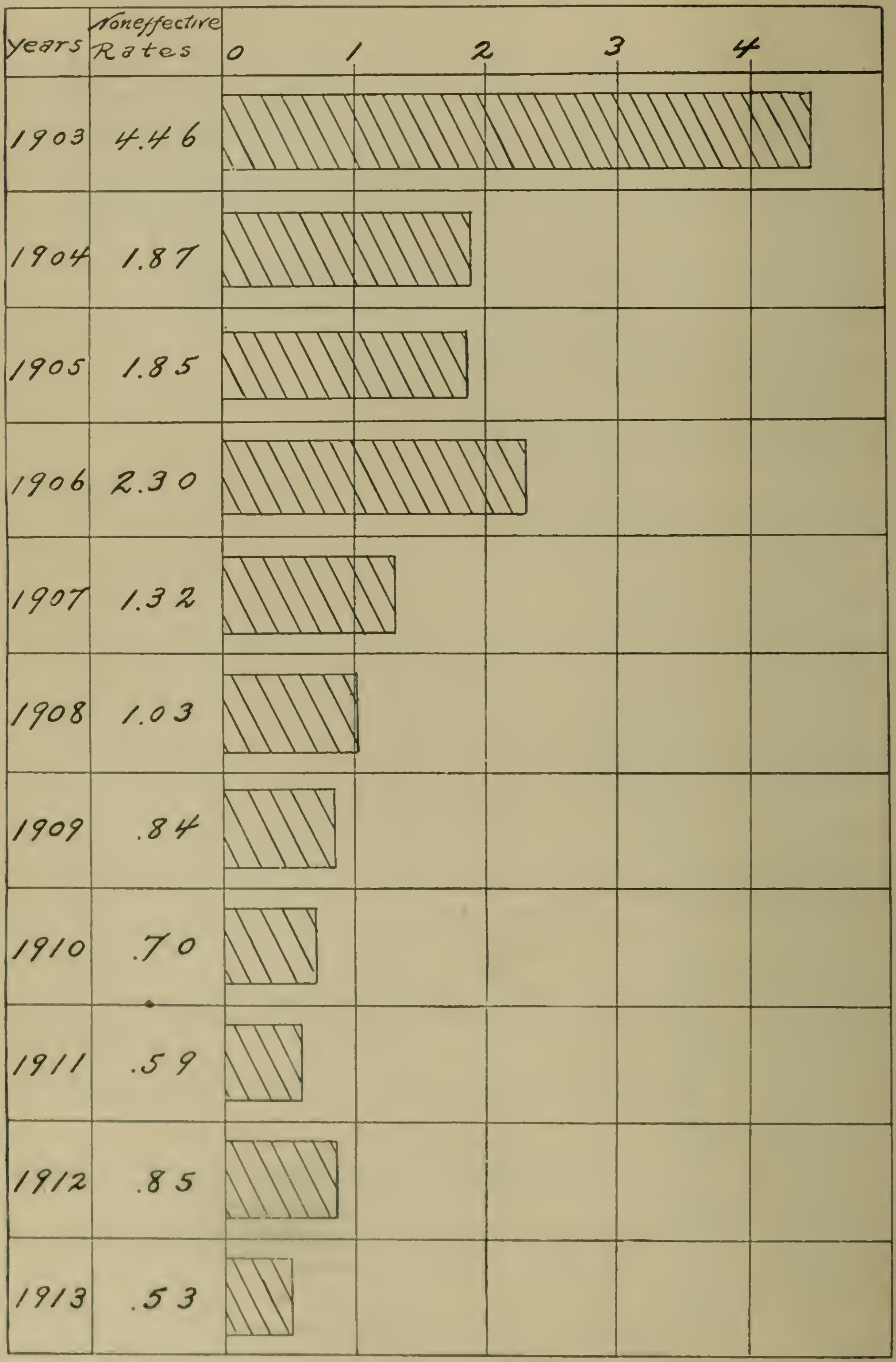


Years	Admission Rates.
1898	694.64
1899	633.34
1900	523.17
1901	365.39
1902	244.63
1903	176.03
1904	84.36
1905	88.85
1906	107.67
1907	63.10
1908	46.33
1909	38.42
1910	28.99
1911	25.18
1912	40.00
1913	24.75

CHART No. III.

Malarial Fevers.
Noneffective Rates.

Noneffective rates for Malarial Fevers, the Army, American troops {enlisted men} years, 1903-1913.



reached the very small noneffective rate of 0.18 and the admission rate of 8.79. In the Philippines on the other hand (Chart No. V) the decrease has not been as steady, and in 1912 and 1913 the admission rates are higher than in 1910 or 1911. The exact reason for this increase during the years mentioned is not known but it was probably due to more exposure in the field because of local maneuvers or expeditions.

The decrease of malaria in the Army has been brought about largely by measures directed against the mosquitoes transmitting the disease, and the protection of man from the bites of these insects. Quinine prophylaxis has probably had but little to do with this reduction, as the use of this method has been very limited. Neither has the control of treatment by microscopic examinations of the blood and the treatment of "carriers" and latent infections operated to any extent in reducing the disease in the Army, as these methods have been very little used, and it is believed that had these methods been widely employed the reduction of malaria would have been much more marked and much more rapid than it has been.

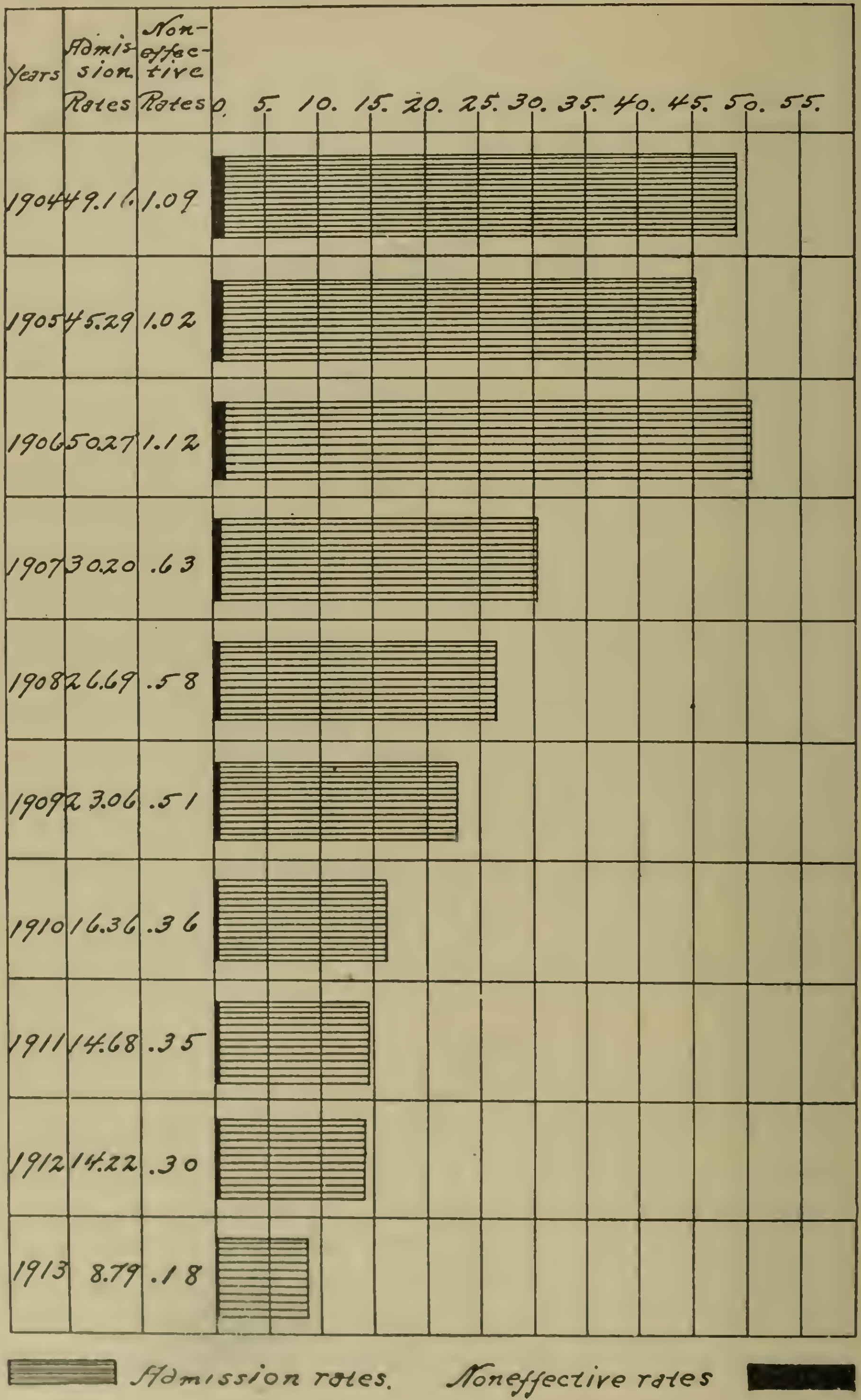
The methods of prophylaxis adopted in different localities must vary with the peculiar conditions present in each region, and common sense must be used here as in every other procedure for the prevention of disease. High-flown theories must give place to a calm study of the situation and the means most applicable and best adapted to fighting the infection. Under some conditions we may be able to practically eradicate mosquitoes, while under others this measure may be impossible, and quinine prophylaxis will have to be substituted, together with measures for the protection of man from the bites of mosquitoes. In many, if not most, localities the best results will be secured by the combination of several prophylactic measures, and I am not at all in sympathy with those who insist that either upon the destruction of mosquitoes or the prophylactic use of quinine alone we must depend for success in the prevention of the malarial fevers.

The prophylaxis of malaria, to be successful, must rest upon a thorough knowledge of the etiology of these infections. In the past much effort has been wasted and money uselessly expended in foolish attempts at prophylaxis by individuals possessing a very superficial knowledge of either the parasites causing the disease or the insects transmitting the infection, and most of the unfavorable reports regarding various methods of prophylaxis, if carefully studied, will be found to be based upon insufficient evidence furnished by those unacquainted with the real facts regarding the etiology of malaria.

A knowledge of the morphology and life cycle of the parasites causing malaria and of the mosquitoes transmitting the disease is

Chart No. IV.

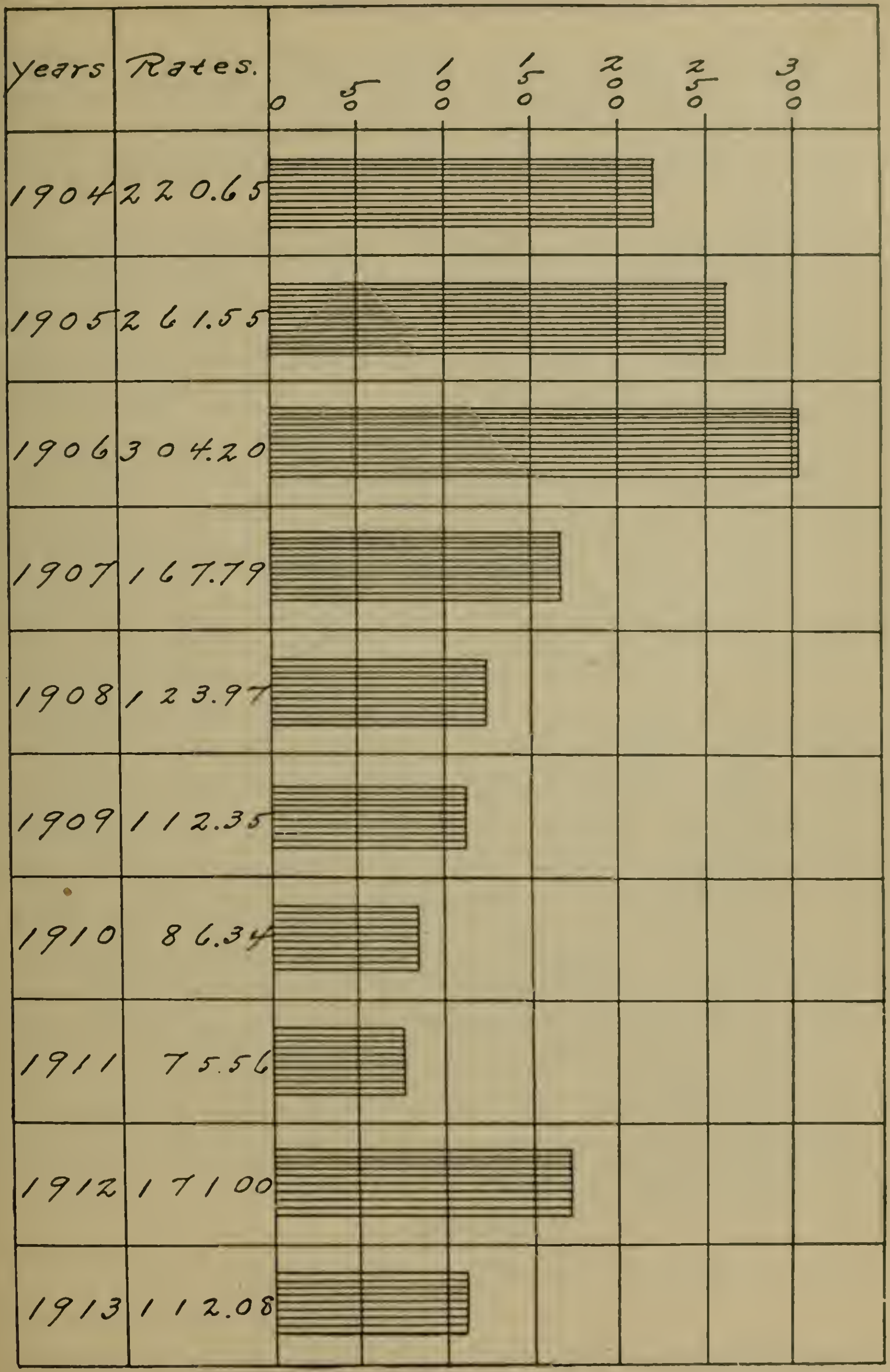
Malarial Fevers.
Admission and Noneffective Rates.
Admission and Noneffective rates for Malarial Fevers for the United States, American Troops, {enlisted men} years, 1904–1913.



Years	Admission Rates	Noneffective Rates
1904	49.16	1.09
1905	45.29	1.02
1906	50.27	1.12
1907	30.20	.63
1908	26.69	.58
1909	23.06	.51
1910	16.36	.36
1911	14.68	.35
1912	14.22	.30
1913	8.79	.18

Chart No. V.

Malarial Fevers.
Admission Rates.
Admission rates for Malarial Fevers for the Philippine Islands, American Troops {enlisted men} years, 1904–1913.



absolutely essential to one who hopes to achieve success in prophylaxis. This does not mean that one must be a professional protozoologist or entomologist, for a good working knowledge of these subjects may be obtained from the careful study of the blood from a few cases of malaria and from the investigation of the structure and habits of a few species of mosquitoes. One should be able to recognize the various forms of the malaria plasmodia occurring in the blood of man and also be able to differentiate mosquitoes belonging to the *Anophelinæ* from other mosquitoes, and, fortunately, this knowledge may be easily acquired by anyone who has access to the necessary material.

As the first step in any successful attempt at the prophylaxis of malaria is the diagnosis of the presence of infection either in man or the mosquito, it is necessary to consider as briefly as is consistent with the importance of the subject the methods of demonstrating the parasites and their morphology and life cycle. The discovery of "carriers" of the infection, so important from a prophylactic standpoint, and the proper treatment of all malarial disease, depends upon the recognition of the plasmodia in the blood of man, while no malaria survey can be called complete which does not include the demonstration of the plasmodia within the mosquitoes of the locality investigated. In the following sections dealing with the plasmodia and the mosquitoes transmitting them I have endeavored to give the facts that are most essential to one working along the line of prophylaxis; and while it has been necessary to describe the morphology of the plasmodia I have limited myself as much as possible in the description, placing special emphasis upon the forms of the plasmodia that infect the mosquito and that may also be demonstrated in the blood of man, i. e., the *gametes.* No attempt has been made to describe in detail the anatomy of mosquitoes, but special attention has been paid to the broad points differentiating the *Anophelinæ* from other mosquitoes and to the habits of certain species transmitting the malarial fevers. The methods of demonstrating the plasmodia are those that I have found most useful and can be easily applied by anyone having a knowledge of the microscope and of microscopical technique.

FORT LEAVENWORTH, KANSAS,
July, 1914.

Chapter I.

THE MALARIA PLASMODIA.

Methods of demonstrating the plasmodia.—The parasites causing the malarial fevers may be studied in either the living condition or in stained preparations of blood. For the military surgeon the examination of the fresh blood is of special value, for staining solutions will not always be at hand, and it is most unfortunate, from a military standpoint, that the study of the living plasmodia in fresh blood has been so entirely replaced by the use of stained preparations. While, at permanent posts and base hospitals, where staining solutions can be prepared and used, the stained preparations of blood are to be preferred, every military surgeon should be familiar with the appearance of the plasmodia in fresh blood, for in the field the examination of unstained specimens will be found the most practicable and rapid method of diagnosing malarial infections. Where stained preparations can be made, however, they possess the great advantage that the plasmodia are more easily seen and are less liable to be mistaken for other objects that may be present in the specimens examined.

Apparatus.—The apparatus necessary in making a blood examination for malaria is so very simple, occupies so little space, and is so easily transported, that there is no excuse for its absence even in military operations in the field. A good compound microscope provided with a one-twelfth oil immersion lens, a bottle of immersion oil, microscopic slides and cover-glasses, two or three medicine droppers, a bottle of staining solution, and boiled or distilled water are all that is necessary to make the most exact examination of the blood for malaria. In operations in the field the bottles of staining solution and distilled water could be omitted, the diagnosis of infection being made from the examination of fresh specimens of blood. The one-twelfth oil immersion lens is absolutely essential, for while the larger forms of the tertian and quartan plasmodia and the *gametes*, or crescents, of the aestivo-autumnal fevers may be seen with lower power lenses, the small, hyalin ring-forms can only be well seen when the one-twelfth lens is used.

Preparation of living specimens.—The following procedure is recommended if it is desired to procure *fresh* specimens of blood for examination for the plasmodia. The patient's ear lobe or the tip of the finger is carefully cleaned with alcohol, dried thoroughly, a slight puncture made with a lancet or needle, and the first drop or two of blood allowed to flow away. A very small drop is then taken upon the center of a microscopic slide which has been carefully cleaned and a cover glass placed gently over it. If the slide is clean and the drop of blood small the weight of the cover glass will cause the blood to spread evenly and quickly beneath it: but if it does not, very slight pressure will suffice to spread the blood and will do no harm. If upon examination it is found that the blood cells are in clumps or rouleaux, the preparation should be discarded and one prepared in which the red cells are spread singly and evenly over the microscopic field. The preparations should be examined as soon as possible; but if carefully wrapped in tissue paper, they may be carried in the pocket for several hours without much danger of changes occurring which will obscure the plasmodia; and if the specimens be carefully ringed with vaseline, they will keep for as long as 12 hours. The ear is preferable to the finger for obtaining blood, especially in children, as there is less pain and the patient can not watch the operator during the procedure. At least a half hour should be spent upon the examination of the specimen before a negative report is returned, and at least three or four preparations should be examined. In the vast majority of active infections, however, a few moments examination will disclose the plasmodia, but where a search is being made for latent infections and "carriers" it is not safe to consider a case as negative unless several specimens are carefully examined.

Preparation of stained specimens.—All that is necessary in the way of apparatus for preparing blood smears for staining are microscopic slides and a needle with which to make the puncture in the ear-lobe or finger. After cleansing the ear or finger, as described, a puncture is made with the needle and a small drop of blood caught upon the surface of a clean microscopic slide, near one end; as quickly as possible the end of another slide is placed in contact with the drop of blood, either before or behind it, and the blood allowed to spread along the edge of the applied end. As soon as this occurs the upper or applied slide is pushed or drawn gently along the surface of the slide containing the drop of blood, and when this is properly done a thin even smear is obtained. Several smears should be prepared from each individual examined.

Method of staining.—Many methods have been devised for staining the malaria plasmodia, but I have found Wright's modification of the Romanowsky stain as satisfactory as any, and it is absolutely reliable when the staining solution is properly prepared and used. Considerable time and care are necessary in the preparation of the stain, and this has been urged as an objection to its use, but anyone who will carefully follow the directions that follow will have no trouble in securing a reliable stain, and, in time of active field operations, if it were desired to issue the powder, it could be prepared in large amounts at the various department laboratories and issued in sealed glass tubes, each tube containing enough powder for a definite amount of staining solution, and with the powder could be sent enough of the proper methylic alcohol to make up the amount of solution indicated.

The powder used in preparing the staining solution is obtained as follows: In a flask add 0.5 gram of c. p. sodium bicarbonate to 100 c. c. of distilled water; dissolve thoroughly, and slowly add, while shaking, 1 gram of Grubler's methylene blue; heat for one hour in an Arnold sterilizer after the steam is up, and then cool the solution. A considerable amount of the methylene blue will remain undissolved, but this should be allowed to remain in the solution.

Make a solution of Grubler's yellow aqueous eosin by adding 1 gram of eosin to 1,000 grams of distilled water. Add this slowly, while stirring, to the cooled methylene blue solution which has been poured into a white dish or bowl. The eosin solution is added until a well-marked precipitate appears and the surface of the mixture is covered with a greenish metallic scum. Test repeatedly, while adding the eosin solution, by placing a drop of the mixture upon a piece of white filter paper. When sufficient of the eosin solution has been added a well-marked pink halo should surround the small amount of blue precipitate left upon the paper. Now allow the mixture to stand for 15 minutes and then filter through one small filter paper; the precipitate is saved, dried in a hot-air oven at 60° C., the greenish mass thus obtained powdered, and stored in an air-tight bottle. Large amounts of the powder may be prepared by increasing the amounts of the reagents given, in proper ratio.

The staining solution.—The solution used in staining the blood smears is prepared by taking 0.3 gram of the powder and adding it to 100 c. c. of pure methylic alcohol (this *must* be Merck's reagent alcohol) filter, and add enough alcohol to bring the entire amount to the original 100 c. c. Let stand for an hour or two before using.

Method of use.—Add a few drops of the staining solution to the blood smear and let stand for from three to five minutes. This fixes the specimen. Then add enough distilled water to cause a slight greenish metallic scum to form upon the surface of the solution; let stand for five minutes, wash in running distilled water, and examine when dry. The exact time for staining, after the addition of the distilled water, varies somewhat with different specimens of blood, but a little experience will soon enable one to judge the right time.

The final washing with distilled water is very important, as by it the precipitate formed during the staining process is removed and the differentiation of the staining of the cytoplasm of the erythrocyte and the chromatin of the plasmodia is obtained. The washing should be continued until the specimen becomes a delicate shade of pink or pinkish-brown. If distilled water can not be obtained, thoroughly boiled water may be used instead.

Staining reactions with Wright's stain.—In specimens of blood properly stained with Wright's stain, the red blood corpuscles are stained a brownish-pink or light salmon, while the various leucocytes are stained as follows: The polynuclear leucocytes present a violet nucleus with unstained cytoplasm except for light pink granules; the mononuclears and lymphocytes have a dark ruby-red or violet nucleus, while the cytoplasm is stained blue; the eosinophiles have a violet or bluish-violet nucleus, while the granules are stained red; the mast cells have purplish-black granules and a dark violet nucleus; while the blood plates stain a ruby-red color, with, in most instances, a more or less definite pale lilac margin.

The cytoplasm of the malaria plasmodia stains a robin's egg blue, the vesicular portion of the nucleus remains unstained, while the chromatin of the nucleus stains a ruby-red or brilliant violet color. The pigment generally appears greenish in color in the tertian plasmodia and almost black in the quartan and estivo-autumnal plasmodia.

The Ross thick-film method.—In suspected cases of malaria in which the plasmodia can not be demonstrated by the methods described, the thick-film method of Ross should be tried. This method will be found of special service in the search for "carriers" of the infection and should always be employed in a malaria survey before a locality is returned as free from the disease.

A large drop of blood is placed upon a microscopic slide at or near the middle, and is spread with a needle until it covers an area about one-half inch in diameter. The smearing may be done with a platinum loop, and the film should be made as evenly as possible. The preparation is now placed aside and allowed to dry.

After the film is dry, the slide is placed in a mixture composed of 50 c. c. of commercial ethyl alcohol containing 10 drops of commercial hydrochloric acid, and removed when the hemoglobin is completely dissolved—a process which is usually complete in from 10 minutes to half an hour, varying with the thickness of the blood smear. The preparation is now fixed and should be washed in running water for 15 minutes in order to remove the acid, which entirely prevents staining if any considerable amount remains upon the slide. After washing, the specimen is allowed to dry and stained with Wright's stain in the manner already described. More stain should be used in covering the film, and a longer time should be allowed for staining because of the thickness of the film of blood.

After staining, the preparation is washed in running tap water until no more blue color comes from the film. The specimen is then allowed to dry, after which it is ready for examination.

In specimens stained in this manner it should be remembered that, owing to the dissolving of the hemoglobin by the acid, the cytoplasm of the red blood corpuscles is not distinctly stained, the intracellular plasmodia appearing to be free in the plasma. The entire film is more or less pink in color, the plasmodia appearing as blue bodies containing more or less red chromatin against the pinkish background. The tertian and quartan plasmodia, if beyond the ring stage in growth, appear as irregular blue masses containing granules of red chromatin, while the ring forms appear as blue rings containing one or two red chromatin granules, or as minute, irregular bodies, if viewed at an angle. The *gametes* are easily distinguished, although the crescentic *gamete* of the estivo-autumnal plasmodia often appears distorted. Some experience is required to identify the plasmodia in these thick films, but a little practice will soon enable one to become expert in the use of this very valuable method of demonstrating the malaria plasmodia.

THE MORPHOLOGY AND LIFE CYCLE OF THE MALARIA PLASMODIA.

The malaria plasmodia were first described by Laveran[3] in 1880 and are found in man upon and within the red blood corpuscles. In this situation they feed upon and destroy the corpuscles, producing thus the anaemia always present in every malarial infection, and by their sporulation the symptom complex which we know as the malarial paroxysm. Although the *classification* of these parasites has occupied the attention of zoologists for years, it can not be said that there is yet a complete agreement regarding the exact position of the species causing malaria in man. All are agreed that they belong to the Protozoa, and most authorities place them in the *Sporozoa*, and in the order *Hæmosporidia*. At least three species are recognized by the vast majority of observers—i. e., *Plasmodium vivax* (the tertian parasite), *Plasmodium malariae* (the quartan parasite), and *Plasmodium falciparum* (the estivo-autumnal parasite). The latter species has been divided by many observers into two varieties, the tertian estivo-autumnal plasmodium and the quotidian estivo-autumnal plasmodium. The tertian species should be called *Plasmodium falciparum*, while I[4] have proposed the name *Plasmodium falciparum quotidianum* for the parasite causing the quotidian type of estivo-autumnal malaria, believing it to be a subspecies of *Plasmodium falciparum*.

In describing the malaria plasmodia two distinct life cycles must be considered—first. the human or asexual cycle, called *schizogony*, occurring in man; and second, the mosquito or sexual cycle, called *sporogony*, occurring in the infected mosquito. In each of these cycles of development the morphology of the parasites varies greatly and should be familiar to everyone engaged in the prophylaxis of the malarial fevers.

In the following descriptions the morphology of the various species of human plasmodia will be first given as observed in living preparations and then as observed in stained preparations. The forms pertaining to the human cycle of development will first be described and then the forms concerned in the mosquito cycle.

Morphology of Plasmodium vivax (*the tertian parasite*) (*Schizogony or human cycle.*—As is well known this species of malaria plasmodium completes its cycle of development in the blood of man in 48 hours and produces the well-known type of malarial fever associated with a chill and fever occurring every other day.

The parasite is first observed, in *unstained* preparations, within or upon the red blood corpuscle as a small, nonmotile, hyaline ring or disk, the *trophozoite*, measuring about 2 microns in diameter; its outline is very indistinct, and it is often overlooked owing to lack of amoeboid movement and the delicate veil-like consistency of its cytoplasm. As it grows older, becoming the *schizont*, it develops marked amoeboid movement, but is still indistinct in outline until pigment is developed at the end of from six to eight hours. The pigment is reddish brown in color and arranged irregularly throughout the cytoplasm in the form of very fine granules. As development proceeds the pigment becomes motile, due apparently to currents within the cytoplasm of the parasite, while the amoeboid motion of the plasmodium becomes less pronounced. As growth proceeds the pigment increases gradually in amount and remains active until just before sporulation when it becomes collected in large masses or a single large irregular mass near the center of the parasite.

At the end of 24 hours the plasmodium fills more than half of the infected red corpuscle, contains much actively motile pigment, and varies greatly in shape due to the marked amoeboid activity of the organism. The infected red cell is considerably larger than normal and lighter green in color. At the end of 36 hours the plasmodium has attained its greatest size and practically fills the infected corpuscle. Amoeboid motion is sluggish, but the pigment, which has still further increased in amount, is very actively motile and is distributed in the form of fine granules throughout the cytoplasm. The cytoplasm of the plasmodium is colorless, but the organism is sharply outlined. The infected red corpuscle is almost twice the size of the normal corpuscles surrounding it. At the end of 48 hours sporulation occurs; the pigment becomes collected near the center or to one side of the plasmodium in the form of a compact clump or clumps, and fine radial striations are observed extending from the center toward the periphery of the plasmodium, dividing it into several ovoid segments or spores. As a rule, these spores, in the tertian plasmodium, are arranged in two rows, one row surrounding the center of the plasmodium and another surrounding the first row; but often the spores are arranged irregularly and are always devoid of pigment. They vary in number from 12 to 24, or even more, but the average is from 16 to 20. The spores are known as *merozoites* and when free in the blood plasma measure from one-fifth to 2 microns in diameter, are oval in shape, hyaline in appearance, and present a spherical, refractive center, and a less refractive mass of protoplasm surround it. The *merozoites* are capable of infecting the red blood corpuscles and thus the human life cycle of the plasmodium is continued.

EXPLANATION OF PLATE 1.

Figure 1.—*Plasmodium vivax.* (Tertian plasmodium.) Young forms or the so-called "ring forms." Wright's stain. × 1200.

Figure 2.—*Plasmodium vivax.* Quarter-grown parasite. Wright's stain. × 1200.

Figure 3.—*Plasmodium vivax.* Half-grown parasite. Wright's stain. × 1500.

Figure 4.—*Plasmodium vivax.* Three-quarters-grown parasite. Wright's stain. × 1800.

EXPLANATION OF PLATE 2.

Figure 1.—*Plasmodium vivax.* (Tertian plasmodium.) Pre-sporulating parasite. Wright's stain. × 1800.

Figure 2.—*Plasmodium vivax.* Sporulating parasite. Wright's stain. × 1200.

Figure 3.—*Plasmodium vivax.* Sporulating parasite. Wright's stain. × 1800.

Figure 4.—*Plasmodium vivax.* Sporulating parasite. Wright's stain. × 1800.

EXPLANATION OF PLATE 3.

Figure 1.—*Plasmodium vivax.* (Tertian plasmodium.) Free spores or *merozoites.* Wright's stain. × 1200.

Figure 2.—*Plasmodium vivax.* Fully developed *macrogametocyte* of *Plasmodium vivax.* × 1800.

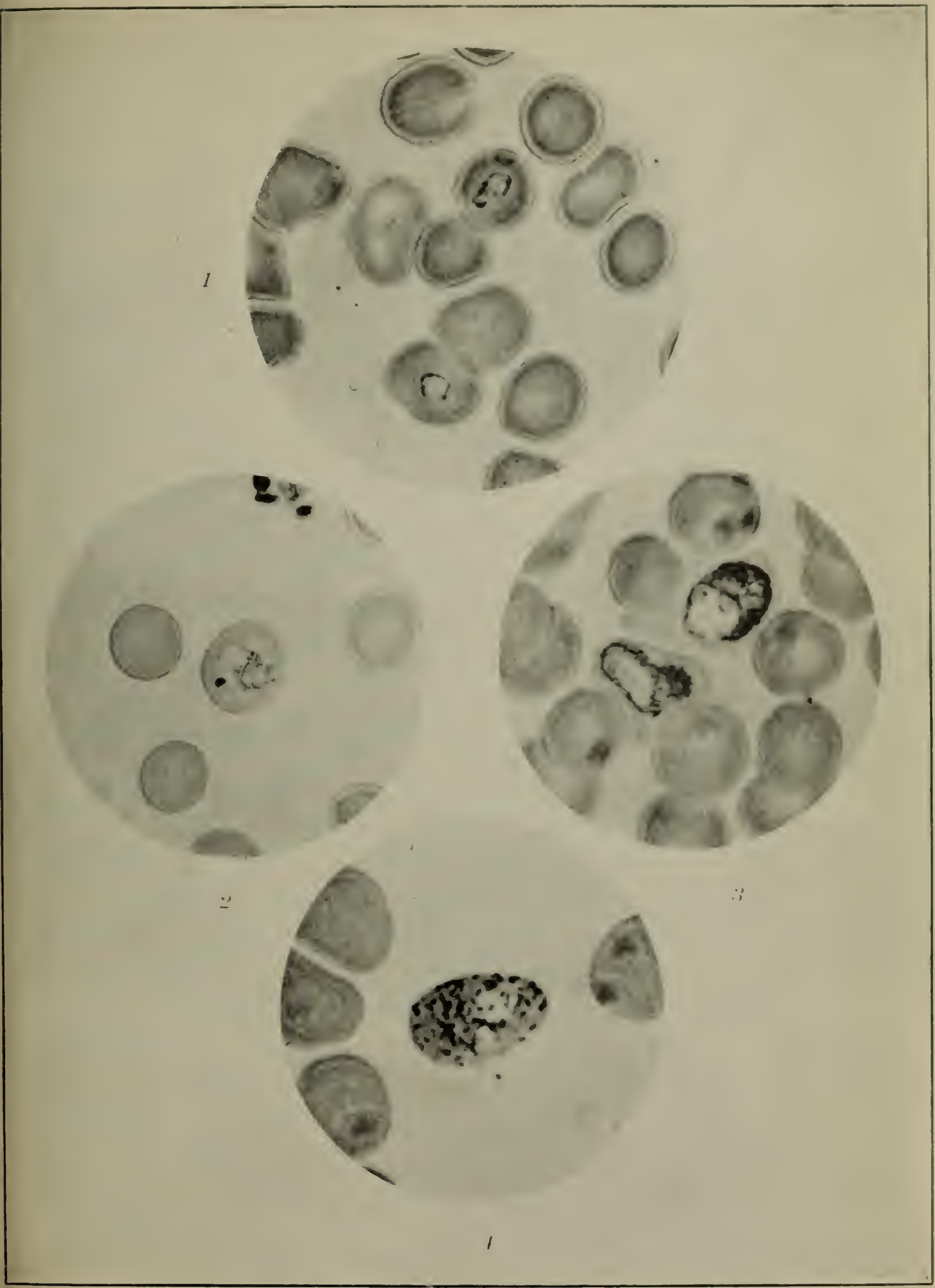
Figure 3.—*Plasmodium vivax.* Fully developed *microgametocyte* of *Plasmodium vivax.* Wright's stain. × 1800.

Figure 4.—*Plasmodium vivax.* Atypical parasite, resembling the *parthenogenetic macrogametes* described by Schaudinn. Wright's stain × 1500.

In preparations *stained* with Wright's stain, the youngest form of *Plasmodium vivax* appears in the red cell as the so-called "ring form" consisting of a delicate ring of cytoplasm stained a robin's-egg blue, at one portion of which is a ruby-red dot of chromatin, the ring inclosing an unstained area through which the salmon or pink of the corpuscle is visible. In those plasmodia in which ameboid motility was present at the time of fixation many irregular forms of the "ring" are observed, due to minute pseudopodia arising from the periphery of the organism. Delicate, blue-stained filaments of cytoplasm may be observed spreading over the infected erythrocyte and the chromatin mass may be situated at any portion of the parasite, quite often within one of the pseudopodia. As the *schizont* becomes larger the blue-stained cytoplasm is observed to contain greenish pigment and the single dot of chromatin has increased until the cytoplasm contains threads and granules of this substance stained a brilliant red. At a certain period of development the chromatin divides into such fine filaments and grains that in the stained preparations the parasites at this stage appear to be almost devoid of this substance but prolonged staining will generally demonstrate a collection of very fine chromatin granules inclosed within an unstained area, the vesicular portion of the nucleus. As sporulation approaches the cytoplasm stains more intensely blue and the chromatin becomes arranged in irregular clumps throughout the cytoplasm. The sporulating plasmodia present a cytoplasm filled with spherical or oval masses of red chromatin and careful examination will demonstrate that each chromatin mass is surrounded by a blue-stained ring of the cytoplasm; the pigment is collected into one or more irregular masses within the organism along with some residual cytoplasm which stains a pale blue. Not infrequently free spores, or *merozoites*, are observed in stained preparations, and are composed of a ring-shaped or almost solid mass of blue-stained cytoplasm containing a small bright red dot of chromatin.

Morphology of Plasmodium malariæ (*the quartan plasmodium*) (*Schizogony or Human Cycle*).—This species of malaria plasmodium completes its development in man in 72 hours, producing that type of the disease characterized by a chill and a rise in temperature at the end of every third day. With the exception of the quotidian form of estivo-autumnal infection, this is the most uncommon form of malaria.

Like the tertian plasmodium, the organism causing quartan malarial infections appears at first, in the *living* specimen, as a small actively ameboid hyaline body within or upon the red blood corpuscle. It will be noticed that ameboid motion is less marked than in the tertian parasite, and that the youngest forms are smaller than the youngest forms of the latter species. The quartan parasite rapidly becomes pigmented, the pigment being dark brown in color, less motile than the pigment of the tertian plasmodium, and arranged around the periphery of the organism. The outline of the parasite, at every stage of development, is much more distinct than is that of the tertian parasite, and the infected red corpuscle, instead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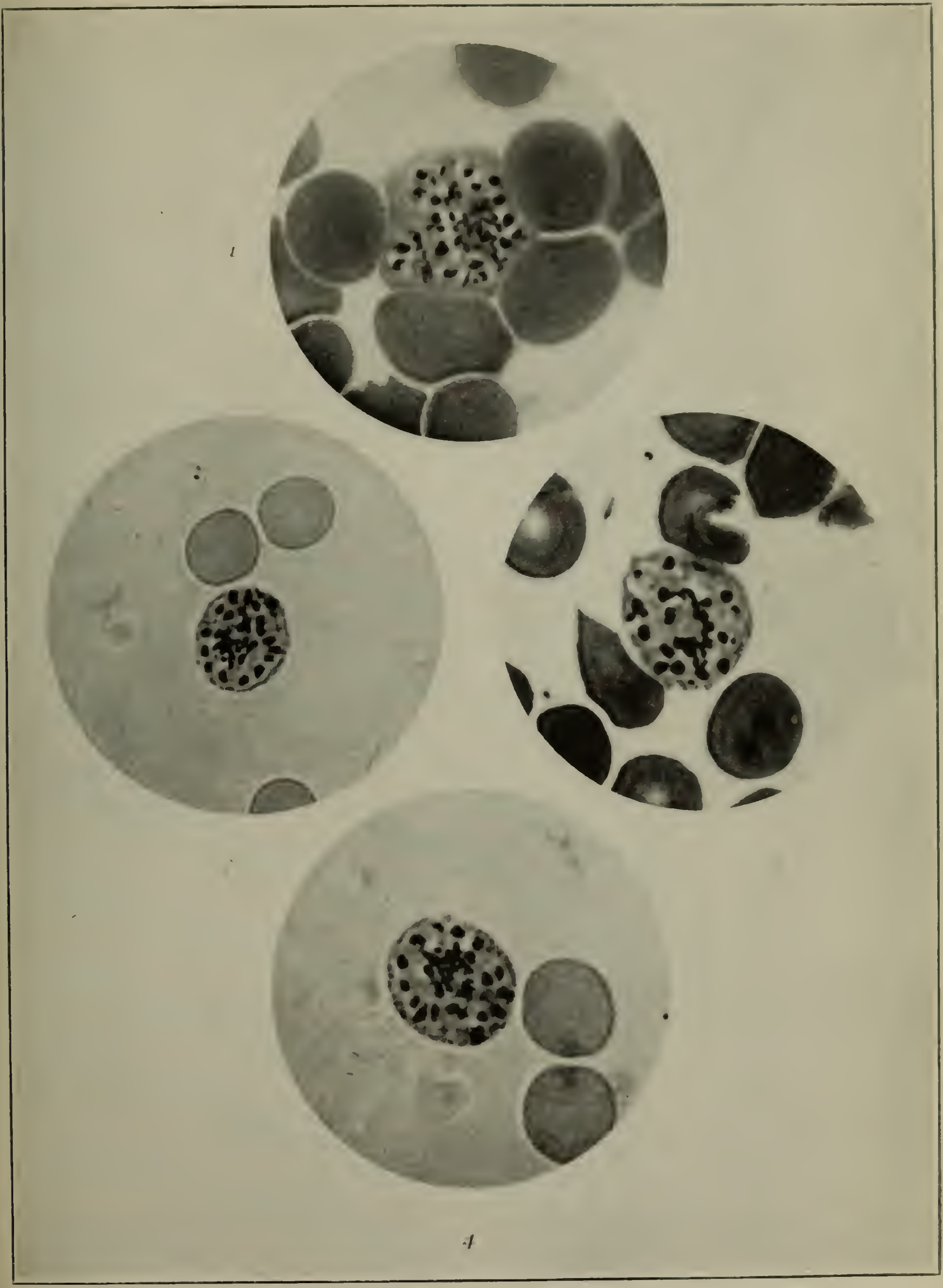
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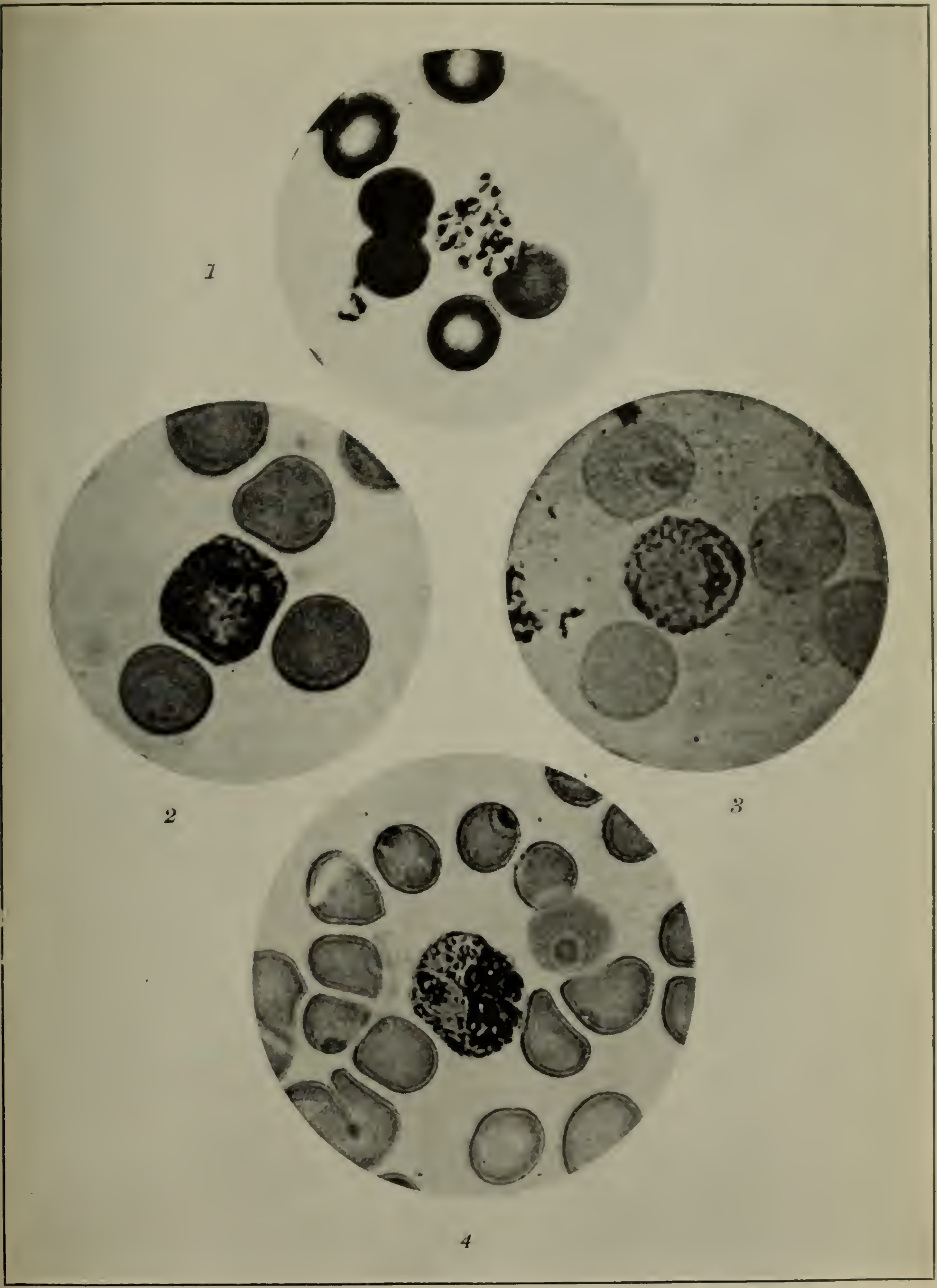

of being larger than normal, and paler in color, as in tertian infections, is normal in size throughout the development of the quartan plasmodium, and slightly darker green in color than normal.

The plasmodium slowly increases in size, and becomes less ameboid. The pigment increases in quantity and becomes collected at the extreme periphery of the organism, and is immotile. The granules of pigment are considerably larger than in the tertian parasite, darker in color, and at no stage of the growth of the organism do they collect in small groups throughout the cytoplasm, as is common in the tertian organism. As growth increases the plasmodium tends more and more to fill the infected red cell, and when full grown—i. e., at the end of 72 hours—it almost fills the cell, a narrow greenish rim of hemoglobin being all that is visible of the red corpuscle. At this stage of its growth the parasite is very distinctly outlined and is much more refractive than is the tertian species; the pigment is motionless and collected around the periphery; the shape is spherical, and ameboid motion has entirely disappeared. At the end of 72 hours sporulation occurs, the pigment being collected in the center, or in a star-like arrangement distributed from the center. Radial striations appear, dividing the organism into 8 to 12, sometimes 16, segments or spores. The spores, or *merozoites*, are generally arranged in a perfectly symmetrical manner around the central clump of pigment, giving the so-called daisy or "Margurite" appearance to the parasite at this stage of development. When sporulation is complete, each *merozoite* becomes free in the blood plasma and, in the human cycle, again invades a red blood corpuscle and repeats the process of development briefly described.

In *stained* preparations, if Wright's method be employed, the quartan plasmodium stains in the same general manner as does the tertian, the chromatin of the nucleus staining a ruby red, and the cytoplasm a robin's egg blue. The youngest *schizonts* are the so-called "ring-forms" consisting of a ring of blue-stained cytoplasm, with a dot or two of red chromatin somewhere near the periphery; while the older forms present the same general staining characteristics of the tertian plasmodium, although the cytoplasm stains more intensely blue and the organism is smaller at every stage of development.

In stained preparations made during the second day of development the very characteristic "band forms" of *Plasmodium malariæ* may be observed consisting of a band of blue-stained cytoplasm stretching across the infected red corpuscle and inclosing a mass of ruby red chromatin. I have never observed these "band forms" in any other variety of malarial infection, and a diagnosis of quartan malarial fever is justified when such forms are observed.

The *merozoites* or spores consist of a deep blue stained mass of cytoplasm containing a compact clump of dark red chromatin situated somewhere near the periphery. In most instances the mass of chromatin is surrounded by a clear, unstained halo representing the unstained portion of the nucleus.

Morphology of Plasmodium falciparum. Tertian estivo-outumnal plasmodium (Schizogony or Human Cycle).—As I have stated, I believe that there are two distinct varieties of the estivo-autumnal plasmodium, the tertian and quotidian. These are distinguishable microscopically, and the symptoms produced by them are characteristic and easily differentiated clinically. The most common species is the tertian or *Plasmodium falciparum*, and this will first be described.

EXPLANATION OF PLATE 4.

FIGURE 1.—*Plasmodium malariæ.* (Quartan plasmodium.) Young parasites. The so-called ring forms. Wright's stain. × 1500.

FIGURE 2.—*Plasmodium malariæ.* Half-grown parasite. The so-called band form. Wright's stain. × 1800.

FIGURE 3.—*Plasmodium malariæ.* Three-quarters-grown parasite. Wright's stain. × 1500.

FIGURE 4.—*Plasmodium malariæ.* Large band form. Wright's stain. × 1800.

EXPLANATION OF PLATE 5.

FIGURE 1.—*Plasmodium malariæ.* (Quartan plasmodium.) Pre-sporulating parasite. Wright's stain. × 1500.

FIGURE 2.—*Plasmodium malariæ.* Sporulating parasite. Wright's stain. × 1200.

FIGURE 3.—*Plasmodium malariæ.* Sporulating parasite. × 1200.

FIGURE 4.—*Plasmodium malariæ.* Young gamete. × 1800.

Plasmodium falciparum appears first within or upon the infected red corpuscle as a round hyaline ring or disk. The infected cell is greenish in color, smaller than the normal corpuscles surrounding it, and generally crenated. These young "ring-forms" are irregular in outline, one portion of the ring being larger than the rest, giving it the so-called "signet-ring" appearance. The organism is quite actively ameboid and only rarely is there more than two parasites observed within one corpuscle. In the course of from 20 to 24 hours the hyaline forms become pigmented, the pigment occurring in the form of fine, reddish-brown granules somewhat resembling those found in the tertian parasite. The pigment is in larger amount than in the quotidian plasmodium and is generally motile. As soon as pigmentation occurs the parasites collect in the internal organs, and it is therefore rare to find the half and fully grown forms of this plasmodium in the peripheral blood.

As growth increases ameboid motion becomes lost and at the time of segmentation or sporulation, which occurs at the end of 48 hours

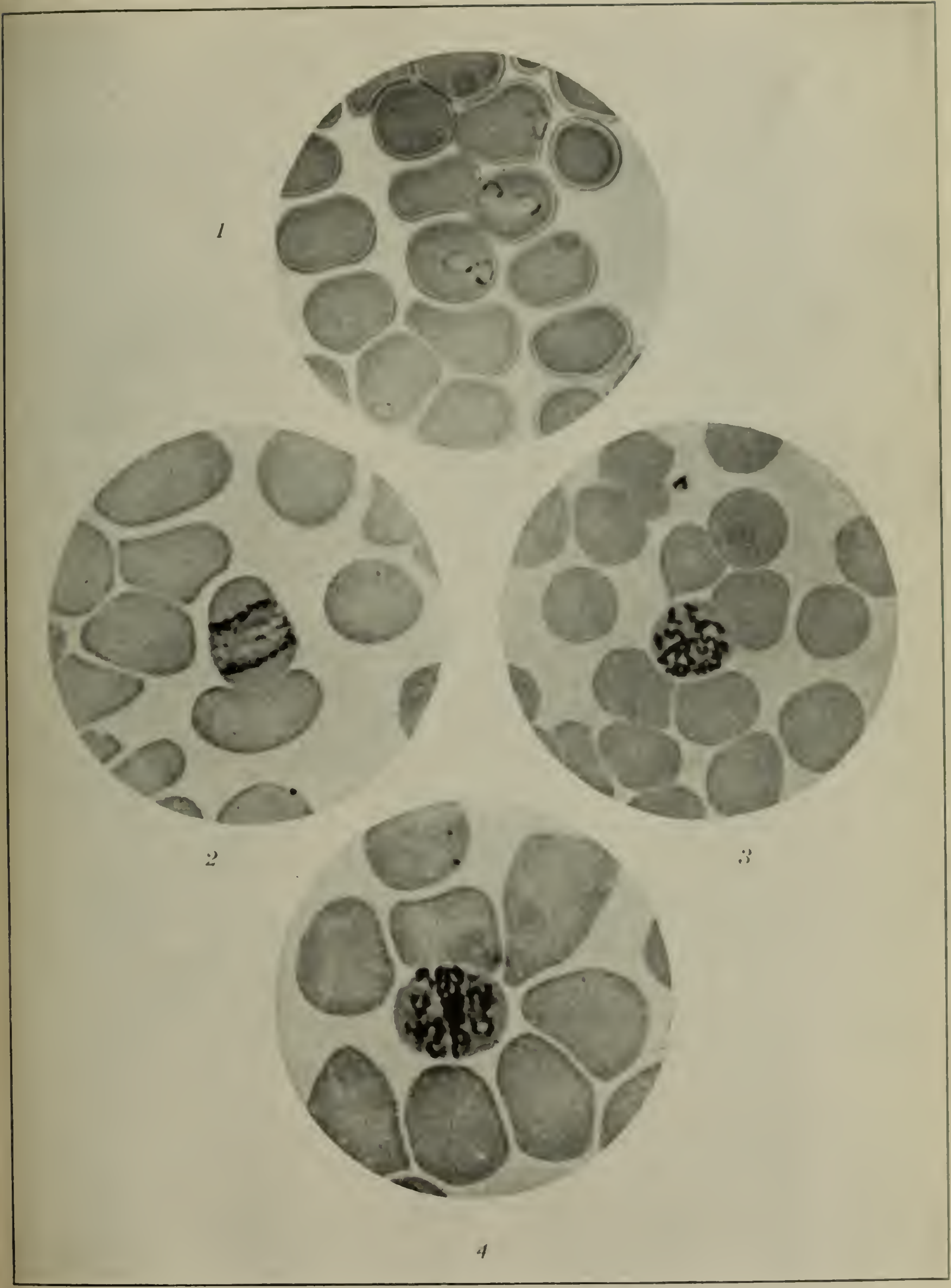
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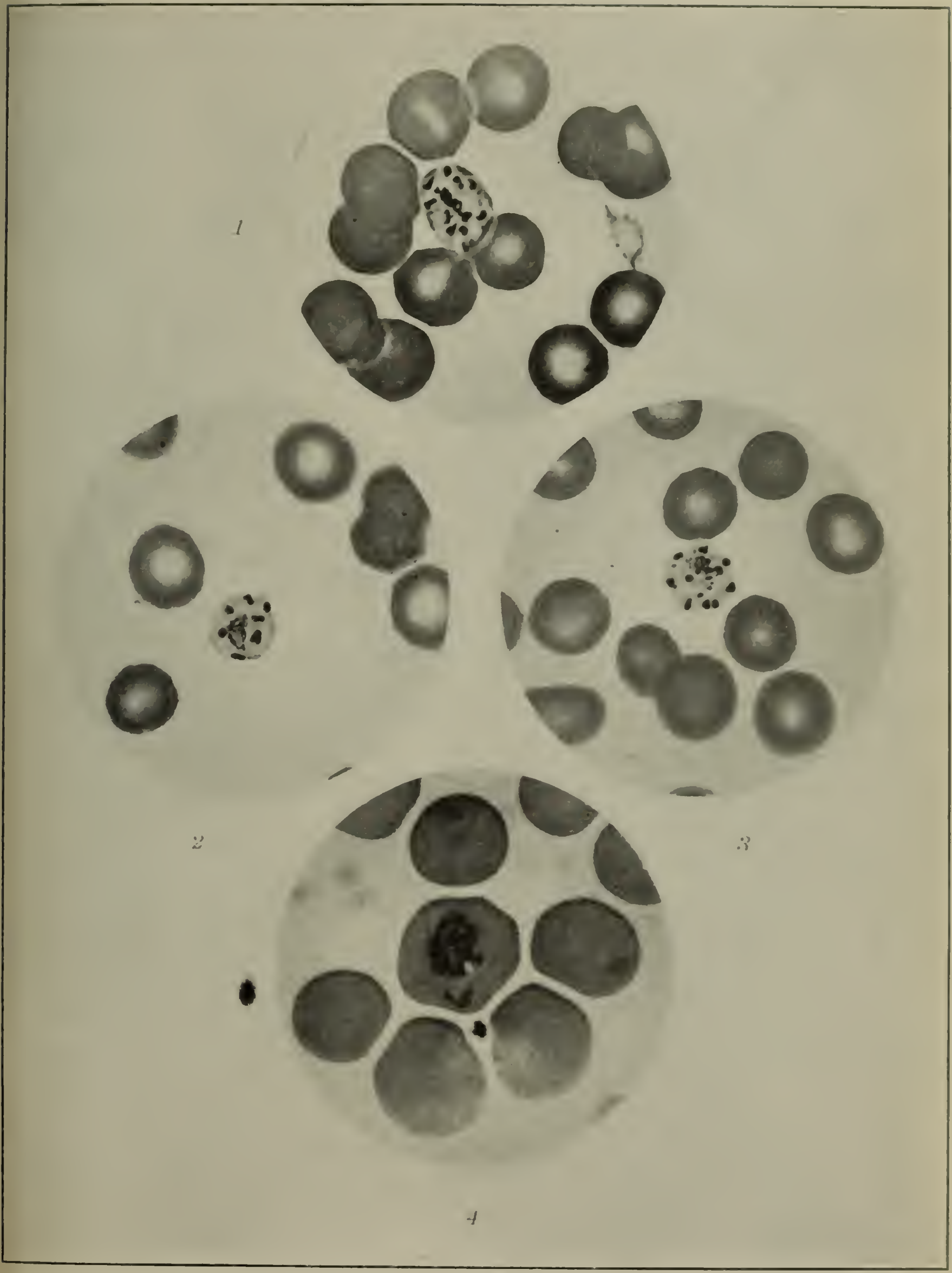
PLATE 5.



in this species, ameboid motility is entirely absent. At this time the fully developed parasite fills slightly more than half of the infected cell, the pigment is collected at the center in a small compact almost black mass, and radial striations are noted dividing the parasite into from 10 to 15 segments or *merozoites*. In some instances as high as 24 *merozoites* have been observed. Sporulation occurs within the red blood corpuscle and considerable of the infected cell is still undestroyed at the time that sporulation begins. The sporulating forms occur very rarely in the peripheral blood, but are present in large numbers in the capillaries of the internal organs, notably the spleen, liver, and brain, and in the bone marrow.

In *stained* preparations, using the Wright method, the staining reactions are the same as occur in *Plasmodium vivax* and *Plasmodium malariæ*, the differential diagnosis resting upon certain morphological features to be noted later in this contribution.

Morphology of Plasmodium falciparum quotidianum. Quotidian estivo-autumnal plasmodium (Schizogony or Human Cycle).—The quotidian estivo-autumnal plasmodium, in the *living* condition, is noticed first within or upon the red blood corpuscle as a very minute ring-shaped or disk-like hyaline body, which upon close inspection is seen to have a very active ameboid motion, the periphery of the parasite continually changing in appearance, due to the protrusion and retraction of minute pseudopodia. The outline of the organism at first is indistinct, but becomes more distinct as growth proceeds, and when the parasite is fully developed the outline is very clear cut and the organism is very refractive. The infected red corpuscle is generally smaller in size than the normal corpuscle, darker green or "brassy" in color, and frequently crenated, and in many instances triple infection of the corpuscle is observed. In the peripheral blood the hyaline, round or "ring-shaped" organisms are those which are most frequently observed, although a small number of the younger pigmented forms are not uncommon. The pigment consists of a small, solid block or mass, almost black in color, situated at some portion of the periphery of the parasite, or at the center, and is never motile. Very rarely the pigment consists of fine granules, but the granules never number more than three or four.

In this species of plasmodium sporulation occurs at the end of 24 hours, and the sporulating forms are very rarely observed in the peripheral blood, although blood from the spleen taken at the proper time will present numerous segmenting organisms. Just before sporulation the plasmodium occupies a little more than one-fourth of the infected corpuscle, thus easily distinguishing it from *Plasmodium vivax* or *Plasmodium malariæ*, which entirely fill the red blood cell when fully developed. As sporulation begins the pigment collects in a small perfectly spherical mass at the center of the parasite, and radial striations may be detected dividing it into from 16 to 18 very minute round or oval segments, or *merozoites.* While in infections with the tertian and quartan plasmodia it is often almost impossible to distinguish the remains of the red corpuscle when sporulation occurs, in this species it can be plainly seen that sporulation occurs before the corpuscle is entirely destroyed, as the sporulating organism occupies less than half of the cytoplasm of the red cell.

In *stained* specimens this species presents the same staining reactions as the other malaria plasmodia, but differentiation is comparatively easy owing to the minute size of this organism.

The morphology of the various malaria parasites so far described is that peculiar to the forms that develop *alone in man*, but in every variety of malarial infection certain forms of the plasmodia are noted that are intended to complete their life cycle within the mosquito, and which, so far as definite evidence now goes, never complete a life cycle within man. These forms are known as *gametes* and probably develop from *sporozoites* in answer to certain influences produced upon the *schizonts* by life within man. While certain authorities believe that the *gametes* are introduced as such by the mosquitoes or develop from certain differentiated *sporozoites*, the great mass of evidence is in favor of their development within man from certain *schizonts*, for it is well known that they do not appear until an infection has lasted for several days, and never appear if the infection is properly treated. These forms will now be described, but before doing so it will be necessary to briefly sketch the life cycle of the malarial plasmodia within the mosquito in order to understand the names applied to the various stages during this cycle of development.

EXPLANATION OF PLATE 6.

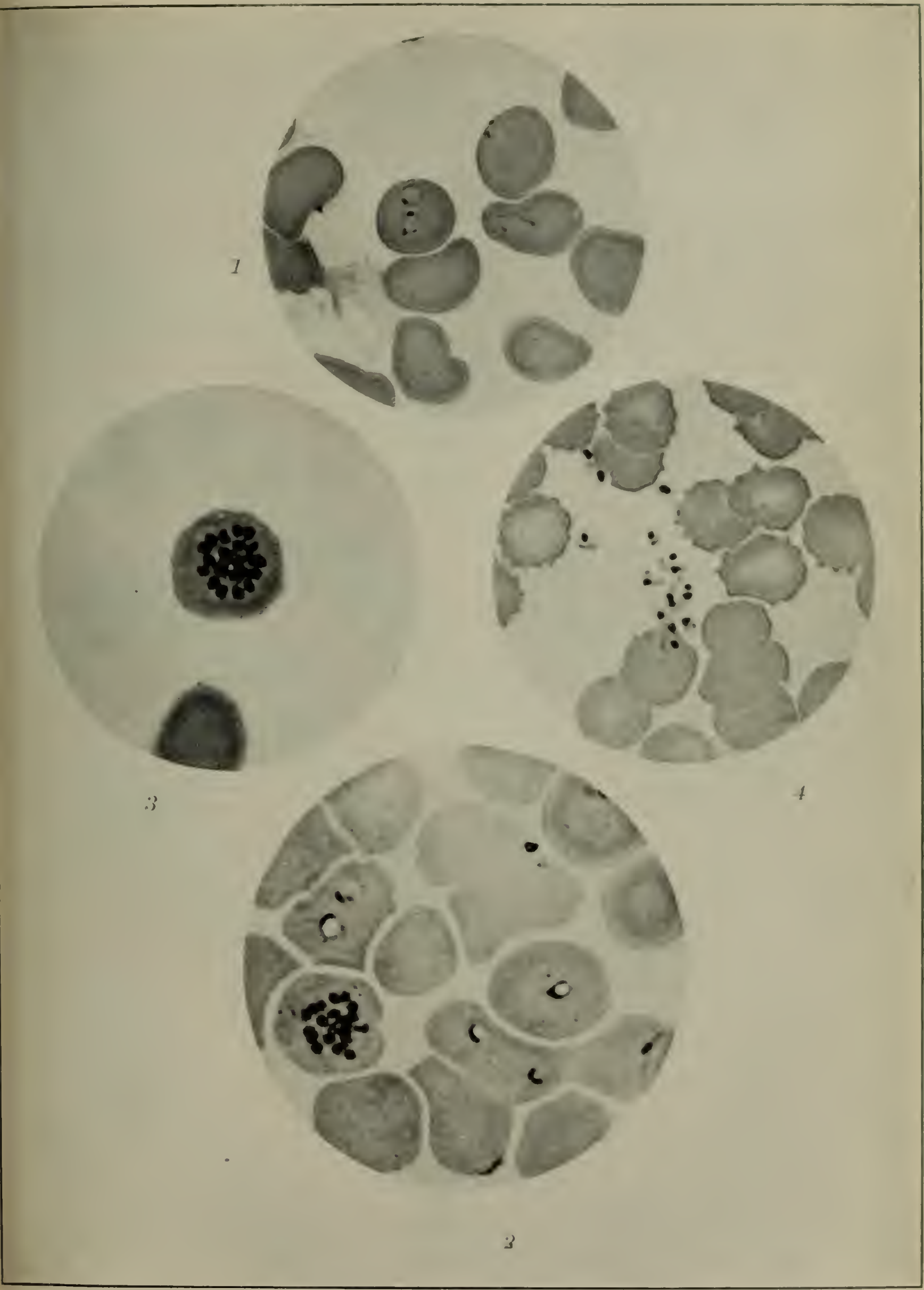
FIGURE 1.—*Plasmodium falciparum.* (Estivo-autumnal plasmodium.) Young parasites. The so-called "ring forms." Wright's stain. × 1200.

FIGURE 2.—*Plasmodium falciparum.* Sporulating parasite and several young "ring forms." Wright's stain. × 1800.

FIGURE 3.—*Plasmodium falciparum.* Sporulating parasite. Wright's stain. × 1800.

FIGURE 4.—*Plasmodium falciparum.* Free spores or *merozoites.* Wright's stain. × 1500.

Development of the malaria plasmodia within the mosquito (*Sporogony or mosquito cycle*).—In tertian and quartan infections certain of the plasmodia are observed that do not sporulate, but remain unchanged in the blood of man until they are removed, when changes occur that normally should occur in the stomach of the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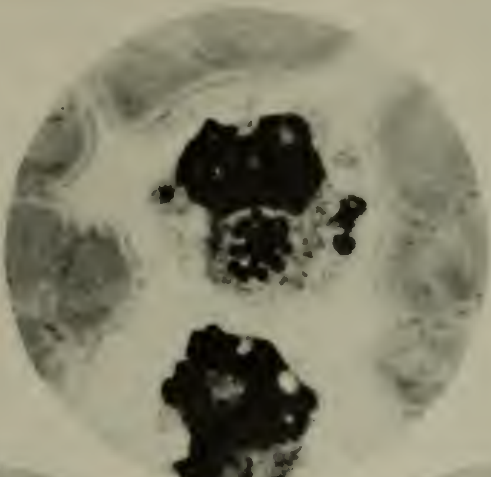

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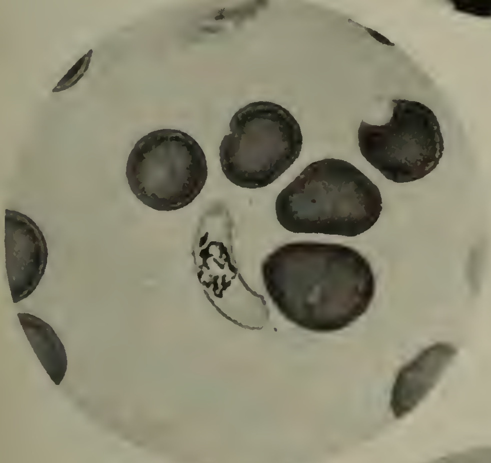

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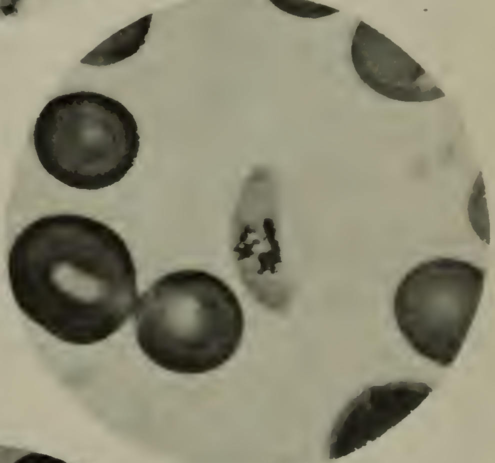

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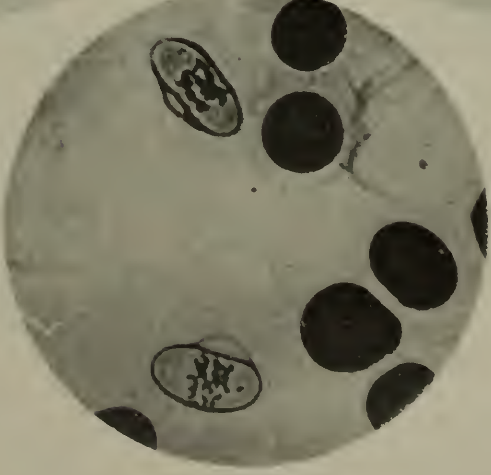

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mosquito. These bodies are circular in shape when fully developed and can be differentiated in both the living condition and in stained preparations. Likewise, in the estivo-autumnal infections certain bodies are developed, of typical crescentic shape, the so-called "crescents," that only undergo development within the mosquito. These bodies while in the blood of man are known as *gametes* and are sexually differentiated, the male being known as the *microgametocyte* and the female as the *macrogametocyte.* When they reach the stomach of the mosquito the male, or *microgametocyte*, liberates flagella, which are known as *microgametes*, and which serve to fertilize the female *macrogametocyte*, which, after certain maturation phenomena, is now known as the *macrogamete.* This process may rarely be observed in preparations of blood removed some time from the body if a little moisture be present on the slide and the temperature be suitable. The fertilization of the *macrogamete* occurs normally in the middle intestine of the mosquito and the result of the fertilization is known as the *sporont.* After a certain period of time the *sporont* elongates and becomes motile and is then known as the *öokinete.* The *öokinete* penetrates the wall of the middle intestine of the mosquito and eventually becomes situated between the adipose tissue and the muscular wall of the intestine. Here the organism becomes circular in shape and forms a cyst known as the *oöcyst.* At this stage the cytoplasm is reticular and granular in appearance, the pigment is reduced in amount, and the entire organism is inclosed in a well-defined capsule. The *oöcyst* is formed at about the third or fourth day after infection of the mosquito. About the fifth or sixth day the *oöcyst* enlarges and within it are formed spherical refractive bodies known as *sporoblasts.* At this stage the organism is so greatly increased in size that it projects from the intestinal wall and may be seen with a low-power objective. At the end of a week the *sporoblasts* have produced a large number of delicate filaments having pointed extremities and containing a small amount of chromatin, which are called *sporozoites.* They are about 14 microns in length and are arranged in a ray-like formation about a central mass in the *sporoblast*, which may contain pigment. The *sporozoites* are finally liberated in the body-cavity of the mosquito by the rupture of the cyst and make their way to the tubules of the salivary glands. At this time, if the infected mosquito bites a man, the *sporozoites* will be inoculated, taken up by the blood stream, and penetrating the red blood corpuscles, develop into *schizonts* and thus begin the human life cycle of plasmodia. The entire life cycle in the mosquito varies from 10 to 14 days in duration.

Having thus briefly reviewed the mosquito-cycle of the malaria plasmodia, we will now consider the morphology of those forms which occur in the blood of man and which are intended to complete their development in the mosquito.

Morphology of the sexual forms of the plasmodia occurring in the blood of man.—The forms of the malaria plasmodia concerned in *sporogony*, or the mosquito cycle of development, which can be demonstrated in the blood of the human host are of the greatest importance in the prophylaxis of these infections, and their recognition essential in any scientific campaign against malaria. The presence of these sexual forms proves beyond question that the individuals in whom they occur are infective to mosquitoes, and that they are thus true "carriers" of malarial disease. The proper treatment of these "carriers" is thus dependent upon the differentiation of the sexual forms or *gametes* and no malaria survey can be considered complete unless the percentage of individuals showing *gametes* is ascertained and proper measures be taken to render them harmless. As already stated, the *gametes* are sexually differentiated, the male being called a *microgametocyte* and the female a *macrogametocyte*.

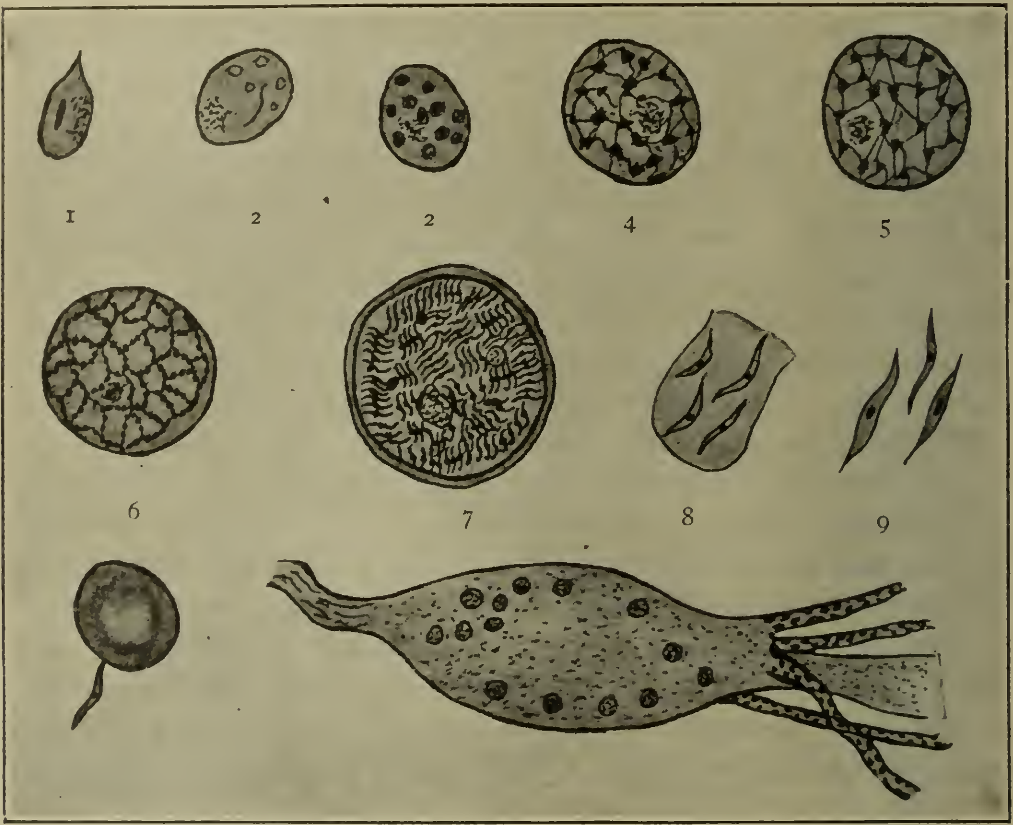


FIG. 1.—Development of Plasmodium vivax within the mosquito. 1, Ookinete; 2, oocyst; 3, 4, 5, oocysts showing the development of sporoblasts; 6 and 7, oocyst showing development of the sporozoites, which are fully formed in 7; 8, sporozoites within a cell of the salivary gland; 9, sporozoites; 10, entrance of sporozoite into a red blood corpuscle; 11, middle intestine (stomach) of mosquito, showing several oocysts in the wall of the organ. (Original.)

but for convenience of description I shall refer to them as the male and female *gamete* respectively.

While no true development of the *gametes* occurs within man, if blood containing them be removed from the body, the male *gamete* frequently undergoes flagellation and liberates the *microgametes*, a process normally occurring in the middle intestine of the mosquito. In very rare instances the fertilization of the female *gamete* by one of these *microgametes* may be observed in the blood after removal from the body, but this can only be regarded as an accidental occurrence, as it normally occurs only within the infected mosquito. The differentiation of the sexual forms or *gametes* is not a very difficult matter, although the opposite opinion appears to be generally prevalent. The estivo-autumnal *gametes*, because of their *crescentic* shape when fully developed, are easily recognized, even by a novice in malarial parasitology, but the intracorpuscular stages in the development of the *gametes* of all of the species of plasmodia are more difficult of recognition, although with a clear knowledge of their morphology and a little practice all of the stages of development may be differentiated in stained preparations of blood. The fully developed *gametes* of *Plasmodium vivax* (the tertian plasmodium) and of *Plasmodium malariæ* (the quartan plasmodium) are easily differentiated if one is acquainted with their morphology.

In considering the morphology of the *gametes* it will be necessary to describe that of each species, as observed in both fresh and stained specimens of blood. The description given will include only the salient diagnostic points, and will be found true of the vast majority of organisms, although frequent deviations will be observed due to artefacts produced during the staining process or to developmental anomalies brought about by adverse conditions in the human host. (The stain used was Wright's modification of the Romanowsky method, already described.)

The gametes of Plasmodium vivax (the tertian plasmodium). Fresh preparations.—In fresh preparations it is practically impossible to distinguish the *gametes* of *Plasmodium vivax* from the forms of the human life cycle until they are fully developed. While individual *gametes* may contain a larger amount of pigment, which is coarser in structure, this distinction can not always be made. However, when the *gametes* are fully developed they may be easily distinguished, even when unstained, from the fully developed forms of the human cycle, and the male and female forms can be readily differentiated.

The male Gamete or Microgametocyte.—The *living microgametocyte* of *Plasmodium vivax*, when fully developed, measures from 8 to 10 microns in diameter, and almost fills the infected red corpuscle; it is spherical in shape and is more or less filled with dark brown pigment collected in small clumps throughout the cytoplasm. The pigment may be very motile, especially just before exflagellation, and this serves to distinguish it from the female *gamete*, in which the pigment is motionless.

The phenomenon which distinguishes the living *microgametocyte* from the forms occurring in the human life cycle is the process known as flagellation, during which the *microgametes* are finally extruded and liberated from the parent organism. The *gametes* that are about to undergo this change are easily recognized because of the violent activity of the pigment within them, and the undulatory movements of the periphery of the parasite, due to the flagella or *microgametes* moving about within the organism. If such a parasite be watched it will be observed that eventually a number of delicate filaments suddenly make their appearance at the periphery of the organism and lash about in the blood plasma. After a variable time one, or perhaps all, of the flagella or *microgametes* succeed in freeing themselves from the parent body and disappear among the red-blood corpuscles. Sometimes these free *microgametes* are discovered apparently alone in a blood specimen by the movement which they impart to the red corpuscles in their vicinity and have been mistaken for very minute filariæ. Their presence is sufficient to stamp the individual from whom the blood was obtained as a "carrier" of malaria.

The female gamete or macrogametocyte.—The tertian *macrogametocyte* when fully developed measures from 9 to 11 microns in diameter, is circular in shape, and almost fills the infected red cell. The cytoplasm is more granular than is that of the forms of the human life cycle, and the pigment is coarser in character and instead of being distributed throughout the cytoplasm is collected in a wreathlike manner at some distance from the periphery. The pigment is not motile. The arrangement of the pigment is characteristic and is of great value in the diagnosis of this *gamete* in living specimens.

Stained preparations.—While it requires considerable practice to distinguish the *gametes* of the tertian plasmodium from the forms concerned in the human life cycle in living specimens, it is quite easy to make the distinction in stained preparations, and in such preparations even the young *gametes* may be differentiated from the "ring-forms" of the human cycle. The staining reactions of the cytoplasm and nucleus of the malaria plasmodia have already been described, and the only variation that occurs in the staining reactions of the *gametes* consists in the degree of color imparted by the stain to the various forms. The tertian *gametes* when stained with the Wright method consist of a mass of blue cytoplasm, inclosing the red-stained chromatin: the unstained portion of the nucleus is not always distinct, and the *gamete* is considerably larger in every stage of development than the *schizont.* The pigment is more abundant, while the nuclear chromatin shows no evidence of division and distribution throughout the cytoplasm, being arranged in small irregular masses confined to one portion of the parasite, or in fine threads or grains, surrounded by an unstained area, which in turn is surrounded by the blue cytoplasm.

The following points are of service in differentiating tertian *gametes* from the *schizonts*, or forms concerned in the human life cycle: 1. The young *gamete* is never "ringlike" in shape, as the dot of nuclear chromatin is situated *within* the circular parasite instead of at some portion of the periphery. This "bull's-eye" arrangement is characteristic, and any organism presenting it may be diagnosed as a *gamete.* 2. The *gamete* is larger than the corresponding stage in the development of the *schizont.* 3. The pigment in the *gamete* is larger in amount and earlier developed. 4. The chromatin is not distributed in the cytoplasm, but occurs in a clump surrounded by the cytoplasm. 5. *Gametes* never sporulate.

The male gamete or *microgametocyte* varies in appearance when stained with the stage of development. The small, intracorpuscular *gametes* stain a pale blue and contain a large dot of intensely red chromatin situated centrally. The fully developed *microgametocytes* present a very poorly stained cytoplasm, the blue tinge being so faint in many instances as to be distinguished with difficulty, the cytoplasm appearing hyaline. The chromatin is large in amount, and in those organisms about to flagellate it is collected into several masses, which are arranged about the periphery of the organism. The pigment is large in amount and stains a greenish-blue color.

The chromatin in the *microgametocytes* is always larger in amount than in the female *gamete* or *macrogametocyte*, and is arranged in the form of rather thick fibrils collected in irregular masses in the cytoplasm, but all of them surrounded by a single achromatic zone, except just prior to exflagellation.

The *female gamete* or *macrogametocyte* of the tertian plasmodium stains a very intense blue, and this alone serves to distinguish it from the male *gamete* or the *schizont*, neither of which stain so intensely. The chromatin in the smallest forms appears as a single red dot situated near the center of the organism, while in later stages of development several dots or rods of this substance are present, situated near the periphery and surrounded by an achromatic zone. The chromatin is never distributed in the cytoplasm as in the *schizonts* or in the male *gamete* just prior to flagellation. The pigment is almost black in color, occurs in the form of minute rods, and is arranged in irregular masses near the periphery or in a wreath about the center of the organism.

The tertian *microgametocyte* may be distinguished from the *macrogametocyte*, in *stained* specimens, by the pale blue staining of the cytoplasm as compared with the deep blue of the *macrogametocyte*, the larger amount of chromatin, collected in masses and surrounded by an achromatic zone, and the presence of several irregular masses of chromatin, situated near the periphery, when the organism is about the flagellate. In the young *gametes* it is impossible to distinguish between the male and female forms, except by the staining reaction of the cytoplasm, the male staining a very pale blue, while the female stains a deep blue.

The gametes of Plasmodium malariæ (the Quartan Plasmodium).—The gametes of *Plasmodium malariæ* are very similar to those of *Plasmodium vivax*, which have just been described, and for this reason require no extended description. Allowing for the difference in the size of the two species, the staining reactions, and the differentiation of the male and the female forms are practically identical, and the description of one can be used for the other if it be remembered that the quartan *gametes*, at every stage of development, are much smaller than the tertian.

The gametes of the estivo-autumnal plasmodia.—The sexual forms, or *gametes*, of *Plasmodium falciparum* and *Plasmodium falciparum quotidianum* are commonly known as "crescents," and are easily distinguished from any other form of plasmodium. The presence of these crescents in the blood at once stamps the individual as a "carrier" of malaria, but the early stages of the estivo-autumnal *gametes* are not crescentic in shape, and at this time it is impossible to differentiate them from the quartan *gametes*, as they are similar in structure and in size. When fully developed the crescents are easily recognized, and the male and female forms can be differentiated with little trouble.

What has been said regarding the appearance of *gametes* of tertian malaria in the earlier stages of development is equally true of the *gametes* of the estivo-autumnal plasmodia, and it is only after they have assumed the crescentic shape that they can be said to differ in morphology from the tertian or quartan *gametes*, if we except their size, which is slightly smaller than the quartan and much smaller than the tertian *gamete*. It will not be necessary, then, to describe the early stages of development of these bodies, but only their morphology after the typical crescentic shape has been acquired. This occurs while the parasites are still within the infected red corpuscle, and as the organism gradually enlarges the infected cell shrinks about it, forming an envelope, which is most noticeable between the poles of the crescent, where it forms what is known as the "bib" of the crescent.

As the *gametes* of the tertian and quotidian estivo-autumnal plasmodia are identical in morphology, except that the quotidian *gametes* are considerably smaller than the tertian, they will not be described separately, and only the points of diagnostic importance will be touched upon in the description of these stages of development.

In the *living* condition the estivo-autumnal *gametes*, after reaching the crescentic stage, are distinguished by their typically crescentic outline and by the fact that they appear to be extracellular, in the vast majority of instances. The cytoplasm appears granular in structure, the female form being more granular than the male, and the pigment is dark brown in color and either distributed throughout the cytoplasm or collected near or at the center of the crescent. The male crescent, or *gamete*, is easily distinguished from the female by its plump kidney-like shape, the female crescent being long and slender. These bodies are very easily recognized in unstained specimens of blood and in regions where estivo-autumnal malaria is endemic a considerable proportion of the inhabitants will be found to show them in their blood.

EXPLANATION OF PLATE 7.

PLATE 7.

FIGURE 1.—Phagocytosis of sporulating *Plasmodium falciparum*. Wright's stain. × 1800.

FIGURE 2.—*Plasmodium falciparum*. A *macrogametocyte*. The female crescent or gamete. Wright's stain. × 1200.

FIGURE 3.—*Plasmodium falciparum*. A *macrogametocyte*. The female gamete or crescent. Wright's stain. × 1500.

FIGURE 4.—*Plasmodium falciparum*. A *microgametocyte*. The male gamete or crescent. Wright's stain. × 1200.

In *stained* preparations the crescents present the same staining reactions as do the *gametes* of the tertian and quartan parasites, the male crescent staining a pale blue while the female stains intensely. The following features serve to distinguish the estivo-autumnal *microgametocytes* (males) from the *macrogametocytes* (females):

1. Shape: The plump kidney shape, the *macrogametocyte* being long and slender.
2. Staining reaction: The pale blue staining of the cytoplasm, the *macrogametocyte* staining deep blue.
3. Chromatin: The arrangement of the nuclear chromatin in the form of a loose network, the chromatin of the *macrogametocyte* being situated at the center of the crescent in a dense mass.

4. Pigment: The distribution of the pigment throughout the cytoplasm, the pigment of the *macrogametocyte* being concentrated at or near the center.

5. Size: The *microgametocytes* are shorter and broader than the *macrogametocytes.*

I do not consider it necessary to describe more minutely the morphology of the estivo-autumnal *gametes*, as their crescentic shape is sufficient to distinguish them in either fresh or stained preparations of blood, and as their recognition is only of importance in malaria prophylaxis, this end will be attained by attention to the diagnostic points already mentioned. For a more detailed description the reader is referred to any of the modern works dealing with the malarial fevers.

It should be remembered that after the crescents reach the middle intestine of the mosquito the crescentic shape is lost; they become circular in outline, the male crescent flagellates, and the flagella, or *microgametes*, are liberated and fertilize the female, as in the tertian and quartan parasites, after which a similar cycle of development occurs in the mosquito. The process of flagellation is often observed in blood removed some time from the body, especially if a little moisture is present upon the microscopic slide.

Important differential points in the diagnosis of the species of malaria plasmodia.—The various species of malaria plasmodia may be easily differentiated in both fresh blood and in stained preparations if certain morphological peculiarities of the plasmodia and the cells infected by them be remembered. The following points I have found most useful in differentiating the various species:

A. *Plasmodium vivax* (tertian plasmodium).

Unstained preparations.—1. Comparatively large size of parasite after development of pigment. 2. Enlargement of the infected red blood corpuscle. 3. Active ameboid motility. 4. Fine, light-brown or reddish-brown pigment. 5. Number of spores or *merozoites*, 12 to 24. 6. All stages of development present in the peripheral blood.

Stained preparations.—1. Large size, after development of pigment. 2. Increased size of the infected erythrocyte. 3. Presence of Schuffner's dots (eosinophilic granules) in cytoplasm of infected erythrocyte. 4. Number of *merozoites*, 12 to 24. 5. Presence of all stages in the peripheral blood.

B. *Plasmodium malariæ* (quartan plasmodium).

Unstained preparations.—1. Medium size, after development of pigment. 2. Pigment in coarse, dark-brown granules, arranged about periphery of organism. 3. Infected erythrocyte not enlarged at any stage of development. 4. Presence of all stages in peripheral blood. 5. Number of *merozoites*, 6 to 12.

Stained preparations.—1. Medium size of pigmented organisms. 2. No increase in the size of the infected red blood corpuscle. 3. Absence of Schuffner's dots (eosinophilic granules) in cytoplasm of infected cell. 4. Number of spores (*merozoites*), 6 to 12. 5. Presence of all stages in the peripheral blood. 6. Presence of the "band forms."

C. *Plasmodium falciparum* (tertian estivo-autumnal plasmodium).

Unstained preparations.—1. Small size, even when fully developed. 2. No enlargement of infected corpuscle, which is smaller than normal. 3. Small amount of fine brownish pigment. 4. Number of *merozoites*, 10 to 16. 5. Only ring forms and young pigmented forms present in the peripheral blood, and crescents. 6. Crescentic shape of the *gametes*.

Stained preparations.—1. Small size, even the sporulating forms only partly filling the infected cell. 2. No enlargement of the infected corpuscle. 3. Presence of Maurer's dots or basophilic granules in the cytoplasm of the infected cell. 4. Number of *merozoites*, 10 to 16, as a rule, very small and arranged irregularly. 5. Only "ring-forms" and young pigmented forms occur in the peripheral blood, as a rule, together with crescents after the infection has persisted for several days. 6. Crescentic shape of the *gametes*.

D. *Plasmodium falciparum quotidianum* (quotidian estivo-autumnal plasmodium).—The quotidian estivo-autumnal plasmodium differs from the tertian form, in both fresh and stained preparations, by its smaller size at every stage of development, while the *merozoites* number from 6 to 18, the average being from 12 to 14. The organism contains less pigment, which is collected into one or two almost black masses, and the sporulating forms seldom fill more than one-third of the infected red blood corpuscles. The hyaline "ring-forms" are very minute, resembling in this respect the piroplasma.

Objects which may be mistaken for plasmodia in stained and unstained specimens of blood.—There is no one thing more essential to success in the recognition of the malaria plasmodia than a practical knowledge of the miscroscopical appearance of both fresh and stained specimens of normal and pathological blood. It is surprising how often some artefact or other object is mistaken for a malaria plasmodium by medical men from whom such a mistake would not be expected, and it is always due to ignorance of the morphology of the blood, an ignorance that can not be excused, for the blood "we have always with us" and anyone may be become perfectly familiar with its morphology who cares to take the time to make a few preparations and to study them. Mistakes are more apt to occur in examining fresh blood but a little care and practice will enable one to avoid them and with the excellent Wright stain it is inexcusable to mistake any object for a plasmodium in stained preparations.

In *fresh* specimens of blood the following may be mistaken for malaria plasmodia:

Vacuoles.—There is no object more deceiving in fresh blood preparations than a small vacuole within the red corpuscle, especially if the border of the vacuole alter in shape, when the resemblance to the hyalin disk forms of the various plasmodia is really very striking. The greater refraction of the vacuole and the fact that it grows larger and smaller in focussing up and down upon it should distinguish it from any stage in the growth of the malaria plasmodia.

Retraction of the hemoglobin from the edge of the red corpuscle may sometimes cause the area devoid of hemoglobin to resemble a hyalin plasmodium, but it may be distinguished by the lack of ameboid motion and the sharp edge of the hemoglobin layer.

"*Eye-spots*," or areas devoid of hemoglobin, occurring within the red corpuscles are sometimes observed in normal blood, and frequently in typhoid fever, tuberculosis, pneumonia, and other acute infectious diseases. They are apparently due to retraction of the hemoglobin layer of the corpuscle, and may be round, oval, spindle-shaped, or ring-shaped, and situated at any portion of the corpuscle. Many of them are oval and spindle-shaped and contain a dark area at the center resembling pigment. These "eye-spots" have been very often mistaken for malaria plasmodia and have been described by several observers as new blood parasites of man. The absence of distinct ameboid motion and the greater degree of refraction should serve to distinguish them from malaria plasmodia.

Blood platelets.—A blood platelet, if lying upon a red corpuscle, resembles slightly the hyalin disk form of malaria plasmodia, but upon focussing there will be observed a difference in the level of the two bodies, while the platelet has no ameboid motility and is less opaque than the plasmodia.

Granules derived from broken down leucocytes, which possess active Brownian movements, may be confused with the smallest forms of plasmodia if they become attached to, or lie over, the red blood corpuscles. Their smaller size and different structure should render such a mistake impossible.

The normal *lighter colored center* of the red corpuscle, which is often hyalin in appearance in diseases accompanied by anemia, has often been confused with the hyalin malaria plasmodia, and I have several times been shown cells of this character and told that they contained plasmodia. Such a mistake is due to inexcusable ignorance of the morphology of the red blood corpuscle.

Crenations of the red corpuscle may cause some trouble to the beginner if they be looked down upon directly, as they then appear as round, hyalin bodies lying upon the red cell, and are sometimes slightly motile. However, there is no ringlike outline, and when focussed upon they appear as alternately light and dark areas upon the surface of the red corpuscle.

Among other bodies that have been mistaken, in my experience, for malaria plasmodia, and shown to me, may be mentioned yeast cells, bacteria of various kinds, extraneous matter, and degenerating red blood corpuscles possessing slender cytoplasmic processes. The latter have been mistaken for flagellating plasmodia, but the greenish color and lack of pigment should prevent such a mistake.

In specimens of blood *stained* by Wright's method the following have been mistaken for malarial plasmodia:

Blood plates.—There is no object so frequently mistaken for malaria plasmodia in stained preparations of blood as is the blood platelet, especially when it lies upon a corpuscle, but such an error is impossible if one is familiar with the morphology of the platelet. The malaria plasmodia of a similar size may always be differentiated from the platelets by their blue-stained cytoplasm and the solid, compact mass or masses of chromatin which stain a ruby red color. The chromatin of the blood platelet stains a darker color and is distributed throughout the platelet in the form of fine granules or irregular granular masses. If one remembers that any malaria plasmodium the size of a blood platelet consists only of a mass of blue-stained cytoplasm containing a solid spherical dot, or at most two dots, of chromatin, it will be impossible to confuse it with a blood platelet, which has a practically unstained cytoplasm and in which the chromatin is granular and collected in a mass or masses in the cytoplasm. Not frequently blood platelets may be collected in crescentic shaped clumps and these have been mistaken for crescents, but no one in the least familiar with the plasmodia could make such a mistake.

Flaws in the microscopic slide, in which some of the stain has settled, have caused confusion, especially if overlaid by a red-blood corpuscle, but focussing will show that they are on a different level from the corpuscle, and a study of the staining reaction will immediately demonstrate their nature.

Vacuoles in the red cell, which sometimes retain a little of the stain, may slightly resemble some of the stages of development of the plasmodia, but may be easily distinguished from the plasmodia by the absence of the blue-stained cytoplasm and red chromatin always present at every stage in the development of the malaria parasites.

Among other objects which have been confused with the plasmodia in stained smears may be mentioned degenerating erythrocytes and leucocytes, yeast cells, and other microorganisms, nucleated erythrocytes, basophilia of the erythrocyte, and extraneous bodies of various nature. It is perfectly obvious that a knowledge of the appearance of normal and pathological blood in stained preparations will make such mistakes impossible, and this is absolutely essential to one who expects to make microscopic examinations of the blood for the diagnosis, and as an aid in the prophylaxis, of malarial infections. In the military service our entire system of prophylaxis and treatment of malaria should be based upon the recognition of the malaria plasmodia in man and the mosquito, for in this service the material is under absolute control and such a basis for prophylaxis and treatment is possible.

CHAPTER II.

THE MALARIA MOSQUITOES.

The Culicidæ, or mosquitoes, belong to the true flies, or Diptera, and the only insects of this family of interest to us in the prophylaxis of malaria are some of the species belonging to the subfamily *Anophelinæ*, for it is only species belonging to this subfamily that transmit malaria. In this section only those points of interest or value to the student of malaria prophylaxis will be touched upon, no attempt being made to give a complete account of either the anatomy or life history of the mosquitoes, as a whole, or to give descriptions of the species concerned in the transmission of the malarial infections. For a complete discussion of the subject the reader is referred to works of Theobald [5], Howard, Dyar, and Knabe [6], and Ludlow [7].

Geographical distribution of the Anophelinæ.—Mosquitoes belonging to the *Anophelinæ* occur wherever malaria does, but it does not follow that malaria is always present in localities where the *Anophelinæ* are found. In order that malarial infections be present in any locality, the right species of *Anophelinæ* must be present, together with infected individuals, and unless both factors be present the propagation of these fevers is impossible. It may be stated that the geographical distribution of the malaria mosquitoes coincides with the distribution of malaria, and the amount of malaria in any given locality is an index of the number of the *Anophelinæ* present.

This fact is of great importance in the prophylaxis of the disease, as the determination of the presence of anophelines and of the exact species present enables one to avoid localities inhabited by the malaria mosquitoes or to take the proper precautions against infection. Such knowledge is of special value in the military service, as a preliminary "mosquito survey" in the selection of localities for camp sites or for the sites of military posts will often prove of inestimable value, both as regards the health of the troops which occupy them and the cost of maintenance. Several instances have occurred in which this measure was neglected, with the result that the camps or posts so located became hotbeds of malaria and a source of continued and excessive expense, owing to the necessity of maintaining costly prophylactic operations. Where there is no military reason for occupying a malarial locality as a camp site, or as a permanent post, it is the part of wisdom to avoid doing so, and the determination of the species of mosquitoes which may be present and the feasibility of getting rid of them should be as carefully investigated as the character of the water supply, the terrain, or any other feature of the locality.

The *classification* of mosquitoes, as regards genera and species, is still an unsettled question among entomologists, but in the following pages I shall follow that of Theobald, who divides the *Anophelinæ* into several genera, each containing several species. Of the genera given by Theobald, the following contain species that have been proven to transmit malaria: *Anopheles*, *Myzomyia*, *Stethomyia*, *Pyretophorus*, *Arribalzagia*, *Myzorhynchus*, *Nyssorhynchus*, and *Cellia*.

For convenience of reference I have prepared the following table, giving the geographical distribution of the species of mosquitoes which have been proven to transmit the malarial fevers. The table can not be considered as complete, as observations are being continually published demonstrating the transmission of these infections by hitherto unsuspected species of the *Anophelinæ*, but it will serve as a guide to the commonly observed species which transmit malaria in the regions mentioned.

Locality.	Species of malaria mosquitoes.
United States	*Cellia albimanus, Cellia argyritarsis, Anopheles maculipennis, Anopheles quadrimaculatus, Anopheles crucians, Anopheles intermedium, Anopheles pseudomaculipes, Anopheles pseudopunctipennis, Anopheles tarsimaculata.*
West Indies	*Cellia albimanus, Cellia argyritarsis.*
Canal Zone, Panama	*Cellia argyritarsis, Cellia albimanus, Anopheles pseudopunctipennis, Anopheles tarsimaculata.*
Philippine Islands	*Myzomyia funesta, Myzorhynchus sinensis, Myzorhynchus barbirostris, Myssorhynchus fuliginosus, Myzomyia ludlowii?*
Central and South America	*Anopheles albipes, Pyretophorus lutzii, Cellia argyritarsis, Cellia albimanus, Anopheles pseudomaculipes, Anopheles intermedium, Anopheles cruzii.*
Europe	*Anopheles maculipennis, Anopheles bifurcatus, Anopheles superpictus, Myzomyia hispaniola, Myzorhynchus pseudopictus.*
Asia	*Myzomyia culicifacies, Myzomyia listonii. Myzomyia turkhudi, Myzorhynchus barbirostris, Myzorhynchus sinensis, Nyssorhynchus theobaldi, Nyssorhynchus stephensii, Nyssorhynchus fuliginosus, Nyssorhynchus maculipalpis, Pyretophorus jeyporensis.*
Africa	*Myzomyia funesta, Myzomyia nili, Myzorhynchus barbirostris, Myzorhynchus paludis, Cellia pharoensis, Pyretophorus costalis, Pyretophorus chaudoyci.*

If one desires to follow the classification of Howard, Dyar, and Knab, the generic names in the above table should all be replaced by the generic name, *Anopheles*.

The number of infected mosquitoes in malarial regions.—It is obvious that the number of mosquitoes infected in different localities will vary with the number of infected individuals present, the season of the year, certain atmospheric conditions, and the care observed by the inhabitants in protecting themselves from the bites of mosquitoes. At the present time we have no evidence that the infection in the mosquito is hereditary, so that it follows that every infected mosquito must have become infected from a human being, and one infected individual may infect scores of mosquitoes within a few hours. In practice it has been found that even in the worst malarial regions a surprisingly small percentage of mosquitoes examined are found infected, if one considers the actual number of infected individuals present and the apparent chance of infection of the mosquito.

In Italy Celli found only 2.5 per cent of the *Anopheles* examined by himself infected; A. Plehn, in Africa, examined 860 *Anopheles* and found 2.2 per cent infected; La Monaco found about 5 per cent infected; and the Sergents, in Algiers, found 1.6 per cent infected. At Camp Stotsenburg, in the Philippine Islands, the percentage of naturally infected mosquitoes varied greatly, being as high as 35 per cent during the height of the malarial season and as low as 1 per cent at other times.

The species of mosquito in relation to the transmission of malaria.—It is now a well-established fact that certain of the *Anophelinæ* do not transmit malaria and can not be infected experimentally. The observations of Stephens and Christophers in India showed that while 12 of 259 *Myzomyia culicifacies* dissected by them shown infection with malarial *sporozoites*, not a single one of 496 *Myzomyia rossii* showed infection, while Hirshberg found that out of 58 *Anopheles punctipennis* experimentally none developed an infection, while of 48 *Anopheles maculipennis* 8 became infected. In the Canal Zone Darling[8] found that, in his experiments, 70.2 per cent of *Cellia* (*Anopheles*) *albimanus* became infected; 60 per cent of *Anopheles tarsimaculata*, and 12.9 per cent of *Anopheles pseudopunctipennis*. On the other hand, he found it impossible to infect *Anopheles malefactor*, which, as he says, despite its name, is not a factor in the transmission of malaria in the Canal Zone.

From these observations it is evident that even though anophelines may be present in a locality, it does not follow that malaria is present or that the disease could spread if it were introduced. In other words, the right species of *Anopheles* must be present in order to transmit the infection, and hence it follows that the determination of the species present in any locality becomes an important prophylactic measure.

Not only are some of the *Anophelinæ* unable to act as hosts of the malaria plasmodia but some species can only act as host for a certain species of plasmodium, so that the prevalence of the different types of malaria in any locality depends upon the species of mosquito present. Beyer, Pothier, Couret, and Leman[9] have shown that while *Anopheles quadrimaculatus* became infected experimentally with the tertian and quartan plasmodia it was impossible to infect it with the aestivo-autumnal plasmodium, while, on the other hand, *Anopheles crucians* was shown to be a host to the aestivo-autumnal plasmodium but could not be infected with the tertian or quartan plasmodia. Kinoshita[10] found that *Anopheles* *sinensis* could be infected with the plasmodia of tertian and quartan malaria but not with those of aestivo-autumnal malaria, and that the quartan plasmodium only developed in this species of mosquito at low temperatures. He also has shown that *Anopheles listoni* is the great transmitter of the aestivo-autumnal plasmodia in Formosa. Many observers have proven that the common *Anopheles maculipennis* is an efficient host for all of the species of malaria plasmodia.

The observations noted explain clearly why certain localities suffer more severely than others from certain types of malarial infection. Given a locality in which only *Anopheles crucians* occurred and we would have nothing but aestivo-autumnal infections, as this mosquito is unable to transmit the tertian or quartan plasmodia, but if *Anopheles quadrimaculatus* were the only anopheles present, we might have either tertian or quartan infections but no aestivo-autumnal malaria. It is, therefore, evident that a mosquito survey is not only of value in determining whether dangerous species of *Anopheles* are present or not, but that it will also aid us in estimating the probability of the spread of the various types of malarial infection.

General description of the Anophelinæ.—The following brief description of the anatomy of the *Anophelinæ* only includes the points of value in the differentiation of these mosquitoes or that are essential to a clear understanding of the relation that these insects bear to the transmission of malaria.

External anatomy.—All mosquitoes are divided into three well marked areas for purposes of description: the head, the thorax, and the abdomen.

The *head* presents upon each side a prominent compound eye, the space separating the eyes above being known as the *occiput*, and that separating the eyes in front as the *vertex;* the back of the head is called the *nape* or neck. The structures of greatest importance from a diagnostic standpoint attached to the head are the *antennæ* and the *palpi*, for attention to these structures alone is generally sufficient to enable one to distinguish between the *Anophelinæ* and other mosquitoes. The *antennæ* are two jointed structures arising from the head and vary in length and structure. In the male they are plumose but in the female they are surrounded by hairs, in most species, so that the sex of a mosquito is easily determined by noting whether the *antennæ* terminate in minute plumes or whether they are surrounded by hairs that become shorter as the end of the antenna is reached. As only the females suck blood the determination of the sex is of importance in any study of the prevalence of malaria.

The *palpi*, two in number, arise from the head between the *antennæ* and the *proboscis*, and are of value in the differentiation of the *Anophelina*, as in this group the *palpi* are of practically the same length as the *proboscis* and longer than the *antennæ*, while in *Culex* and *Stegomyia* the palpi in the female are short, club-like structures, very much shorter than the *proboscis* or *antennæ*. As a practical working rule it may be stated that any female mosquito having *palpi* approximating the length of the *proboscis* belongs to the *Anophelinæ* and, therefore, may be concerned in the transmission of malaria.

The *proboscis*, or sucking and piercing organ, is a complex structure arising from the head between the *palpi*. It consists of seven parts, the labrum, the epipharynx, the hypopharynx, two mandibles or lancets, and two maxillæ, which, when the insect is not biting, are all inclosed in the labium. All of the mouth parts originate beneath the *clypeus*, a chitinous prolongation of the anterior portion of the head. At the base of the *hypopharynx* is situated the so-called *salivary pump* in which the salivary duct empties and is continued beyond it into the *hypopharynx*. The action of this pump is to draw the saliva from the salivary glands into the pumping organ after which it is forced into the channel along the hypopharynx. The saliva is injected into the wound when the mosquito bites and with it the malarial *sporozoites* if the insect is infected.

The thorax.—The thorax is situated between the head and abdomen and is composed of the *mesothorax*, the *scutellum*, the *prothoracic* lobes, and the posterior portion, or *metathorax*. It contains the salivary glands and is of importance to entomologists in the classification of mosquitoes, because of the character of the scales which cover it. The *legs* arise from the thorax, and are six in number, and the two *wings* arise from the upper portion of the thorax and their venation is of great importance in classification.

The abdomen.—The abdomen consists of 10 segments, the posterior two being much smaller than the others and containing the sexual organs. The scales that cover the abdomen in most species are of considerable value in classification to the systematic entomologist, as they vary greatly in shape and arrangement.

The internal anatomy of the Anophelinæ.—The alimentary canal of mosquitoes is divided into a *fore-gut*, a *mid-gut*, and a *hind-gut*. The *fore-gut* lies in the head and thorax and consists of the mouth, the pharynx, and pumping organ, the esophagus and the esophageal diverticula. The *mid-gut* begins in the thorax and extends from the esophageal diverticula to the hind-gut, filling most of the abdominal cavity. It consists of the so-called stomach and the pylorus. The portion of the mid-gut known as the "stomach" is of special interest to the student of malaria prophylaxis, for it is in this portion that the mosquito cycle of the malaria plasmodia begins, the *ookinete* produced by the fertilization of the female plasmodium by the male penetrating the wall of this portion of the intestinal canal and forming the cyst in which are produced the *sporozoites.* This portion of the mid-gut lies at about the level of the sixth abdominal segment.

The *hind-gut* begins at the pyloric dilatation into which open the five Malpighian tubes and ends at the anus. It consists of the pyloric dilatation, the ileum, the colon, and the rectum.

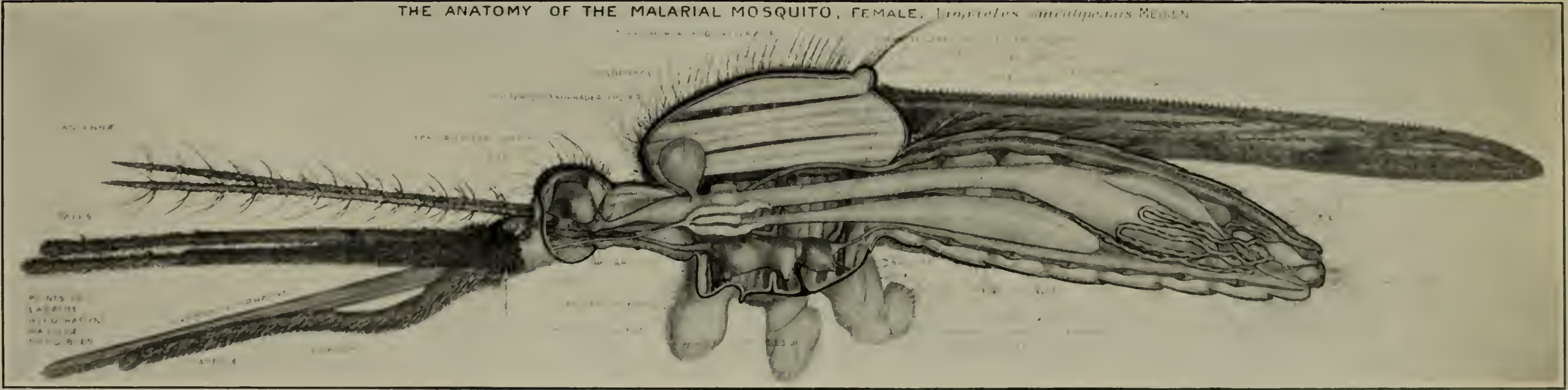
The *genital organs*, while of great importance to the entomologist in the classification of species, will not be described, as they can not be used for this purpose by the ordinary observer.

The salivary glands.—The salivary glands are situated in the anterior portion of the thorax and are of interest because it is through them that the malaria *sporozoites* reach the mosquito's proboscis and eventually the blood of man, being injected into the wound when the insect bites. The glands are two in number, each consisting of acini lined with large granular cells and possessing a central duct which unite, after leaving the acini, to form a common salivary duct which enters the alimentary canal close to the base of the proboscis. It is in the cells lining the tubular salivary glands that the malaria *sporozoites* are found at the termination of the cycle of development of these parasites in the mosquito.

The life-cycle of the Anophelinæ.—The *Anophelinæ*, in common with all mosquitoes, passes through larval and pupal stages before development into the perfect insect and these stages are aquatic so far as we know.

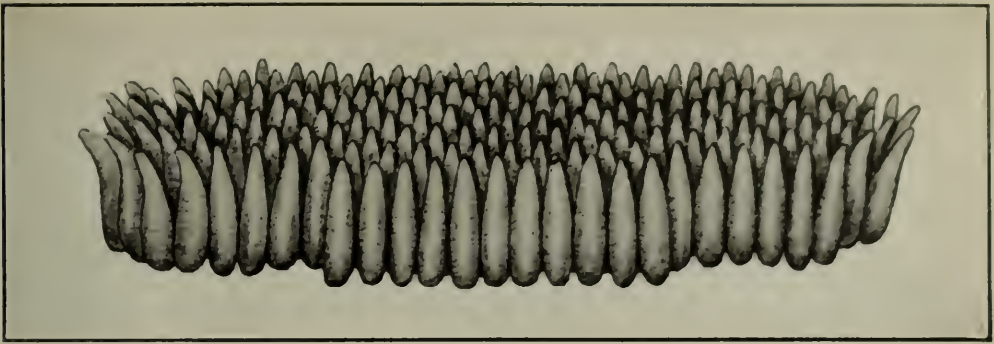
The ova.—The ova of Anopheles are generally laid upon the surface of water but a few species will lay them in wet ground, as I have observed in the Philippines. The eggs are not laid in boat-shaped masses, as in the case of the common *Culex* mosquitoes, but singly, and by adhering end to end geometrical patterns are sometimes produced that are quite characteristic. The distinguishing mark of the eggs of the *Anophelinæ* is the presence of the so-called "float," a hydrostatic organ composed of a partial envelope expanded along the middle of the egg, giving it a very characteristic appearance. These lateral floats are variously marked in the eggs of different species and vary in size but are always easily distinguished and of the greatest service in differentiating the anopheline egg from that of other mosquitoes. The eggs are oval in shape and eggs hatch, in most species, in from one to two days, but this varies so much with external conditions and with the different species that a general statement is hardly justified. From thirty to over a hundred eggs may be deposited by a single female.

The eggs will remain alive in moist mud for considerable periods of time, even as long as 6 days, but can not resist complete drying for over 12 hours, so far as is known. This fact is important, as it indi-


THE ANATOMY OF THE MALARIAL MOSQUITO, FEMALE. *Anopheles maculipennis* Meigen

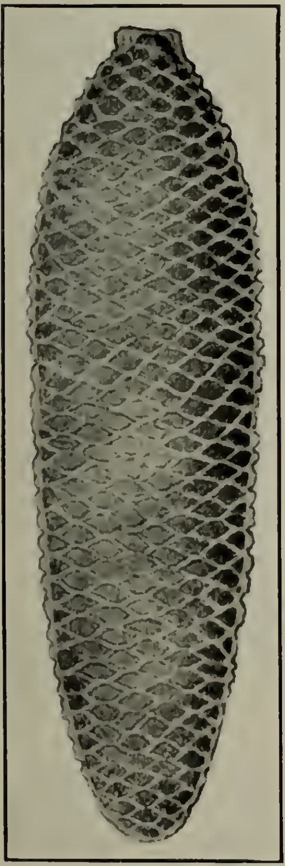
ANATOMY OF THE MALARIA MOSQUITO.

The figure represents a median section of a female. The mouth parts, the antennæ, the alimentary tract, and the nervous and reproductive systems have been left entire. Magnification 20 diameters. From model in American Museum of Natural History. (Dahlgren.)



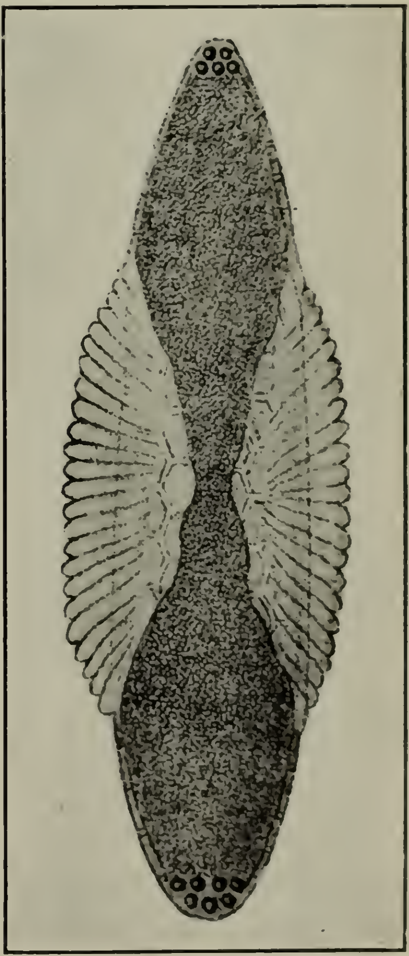
After Howard

Egg raft. *Culex territans* Walk.



After Howard.

Egg. *Stegomyia fasciata.*



After Howard.

Egg. *Anopheles crucians.*

cates that drainage of pools or other small collections of water will not be efficient if the mud remains moist until water again gains access to the pool. The observations of Nuttall and Shipley [11] and of Christophers and Stephens,[12] as well as others, prove conclusively that the eggs of the *Anophelinæ* will remain alive in moist mud for days but that in dried mud they quickly perish.

The larvæ.—The larvæ of the *Anophelinæ* are distinguished from the larvæ of other mosquitoes by the elongated, comparatively narrow head and the absence of the respiratory tube or siphon. Like the adult insect the body is divided into three portions—the head, the thorax, and the abdomen. While in the ordinary *Culex* mosquitoes the head is comparatively broad, in the anopheline larvæ it is narrow and elongated and easily distinguished. The important differential point, however, is the great difference in the breathing apparatus, the long respiratory tube of *Culex* and *Stegomyia* being replaced by openings in the eighth abdominal segment, which, while slightly raised, force the larvæ to lie parallel with the surface of the water. The long respiratory tubes of all other mosquitoes allow them, when breathing, to suspend themselves at an angle with the surface of the

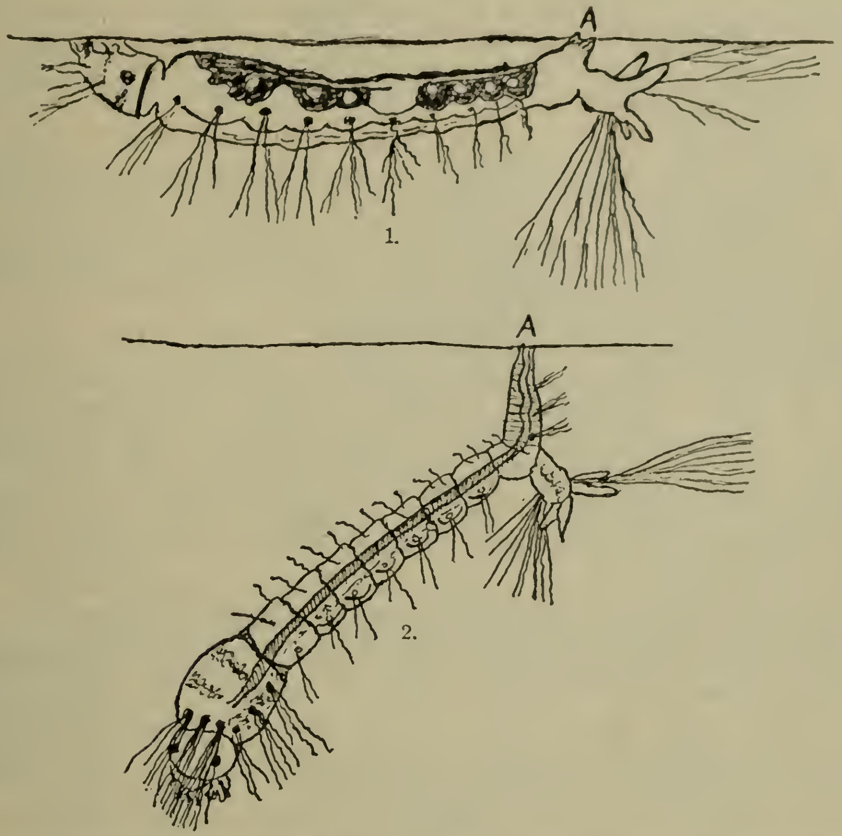


Fig. 2.—Larva of *Anopheles* and *Culex*. 1, Larva of anophelinæ. Note horizontal position in relation to surface of the water, and the absence of syphon (A). 2, Larva of Culex. Note angular position in relation to surface of the water, and presence of the syphon, at A. (Fig. 1, after Howard; 2, after Theobald.)

water, but owing to the absence of the respiratory tube in the *Anophelinæ* the larvæ always lie horizontal to the surface. This fact makes the differentiation of these larvæ very easy, but, as Ludlow[13] has pointed out, other aquatic larvæ have this peculiarity, so that one must be familiar with mosquito larvæ before concluding that anophelines are present.

The larvæ vary in color, but are usually gray or brownish. They molt four times before becoming pupæ, and the length of this stage of development varies greatly, the average probably being from 10 to 14 days, although it has been observed to be as short as a week and as long as 30 days. It varies with different species and with external conditions.

The pupæ.—The pupal stage of development is probably the shortest, averaging about two days, but varying between two and six days according to temperature and other external conditions. The pupæ are not easily differentiated from those of other mosquitoes, and, therefore, will not be described.

The adult mosquito or imago.—After a period of development varying in time, but usually in from two to four days, the pupa rises to the surface of the water, remains there, and the skin over the thorax breaks open and liberates the adult insect. This process has been very accurately described by Hurst[14], to whose work the reader is referred.

Habits of mosquitoes of importance in the prophylaxis of malaria.—A knowledge of the habits of the larvæ and the adult anopheline is of importance in the prophylaxis of malaria, for the better acquainted one is with this portion of our subject the easier will be the application of methods looking to the destruction of these insects.

Habits of the larvæ.—I have already spoken of the position of the larvæ of anophelines being parallel with the surface of the water, and this position is maintained unless the larva is frightened, when it will sink below the surface. It feeds upon floating objects, which are attracted to the mouth by the fringes of the mouth parts producing a current toward the mouth. The larvæ eat both vegetable and animal matter and devour one another.

The larvæ of some species of *Anopheles* are able to *hibernate*, as shown by the observations of Galli-Valerio and de Jongh. They found that the larvæ of *Anopheles bifurcatus* hibernate beneath the leaves of aquatic plants, and that they survived even when in water between two sheets of ice.

Of the *natural enemies* of mosquito larvæ may be mentioned the fresh-water hydras, many aquatic insects, salamanders, and certain species of fish, to be hereafter considered.

Habits of the adult anopheles—Feeding.—The feeding habits of the species of anophelines that frequent the habitations of man are of importance in prophylaxis. It may be stated that while many species of anophelines are of sylvan character, all of the species that have come in contact with man and have continued in association with him are bloodsuckers, and that, even in the sylvan species, blood is a normal food, being obtained from other animals than man. It is not true that a meal of blood is necessary to the female before depositing her eggs or, as has been stated, that the fertilization of the female is impossible unless she has sucked blood. Grassi found that *Anopheles* will bite large animals in preference to small ones—a horse being bitten in preference to a man—and that they bite in the open as well as in habitations. The first meal of blood is taken two or three days after the insect emerges from the pupa, as shown by Darling and Grassi, and they will bite at intervals of a few hours.

It is well known that during rains it is seldom that one is bitten by anophelines, but that after the cessation of the shower they are very vicious. This is especially noticeable in the Tropics during the rainy season. The effect of temperature upon the feeding habits is also very marked, a high temperature apparently stimulating the biting propensities of most species of anophelines.

The *time of day* in which the anophelines bite is an important prophylactic point. Most species of the *Anophelinæ* fly during the twilight hours, and it is during this time that one is most frequently bitten. While this is true, I have seen various species of *Anopheles* biting in the late afternoon, and *Myzomyia funesta*, a common malaria mosquito, biting in the early morning and even at noon in the Philippines.

Anophelines will bite during the night if the temperature is high, as in the hot portions of the Middle West, but where the nights are cool, even though they may be present in great numbers, they bite only during the twilight hours and in the early morning. A beautiful illustration of the twilight habits of the anophelines is noted in the observations upon the Canal Zone regarding the flights of *Anopheles*, in which it was found that the flight of these insects from the propagation area to the town began about 6.30 in the evening and that it ceased before 9 in the evening, while the return flight began at 6 o'clock in the morning and lasted about half an hour.

After biting, the anophelines usually hide out of doors, within a short distance of habitations, beneath tall grass, or within the foliage of bushes and trees. However, they often remain within the habitation, and I have observed hundreds of anophelines in the daytime around the baseboards of toilet sinks and upon clothing in dark closets in the Philippines.

While, as has been said, most anophelines prefer the twilight hours for biting, they will bite at any hour of the day. Chagas and Neiva [15], Smith [16], and Howard [17] all have recorded distances in which biting occurred during the middle of the day, in the sunlight, but prophylactic measures based upon the twilight habit would prevent the vast majority of bites.

Flying distance.—In most of the older publications dealing with mosquitoes it is stated that they do not cover great distances in flight. This statement, in the light of our modern researches, can no longer be considered correct, even in regard to the *Anophelinæ.* In 1909[18], I published a statement that from personal observations I believed that certain species of *Anopheles* often flew from 2 to 2½ miles in order to reach the post where the observations were made, and this statement, being so much at variance with generally received opinions regarding the flight of anophelines, was subjected to much criticism by entomologists. Since then my observations have been confirmed by workers upon the Canal Zone and by James and Christophers in India[19], as well as others, and it is now well recognized that while anophelines prefer to breed near their prey, they will fly long distances in order to lay their eggs or to feed, provided there are no breeding places in the near vicinity.

The experiments of the department of sanitation in the Canal Zone in regard to the flight of anophelines are of special interest and value. In their report they say[20]:

> Adult anopheles were stained with dye and liberated at the swamp. Subsequently some of them were collected on the opposite side of the river, at the locks, and in houses 4,700 feet from the liberating station. It should be stated that the anopheles' flight was decidedly marked and was easily noted by half a dozen witnesses, when their attention had been drawn to it. Even so, not one person in areas thickly infested did note the flight until shown the way to observe it.

Regarding the flight of the anopheles the report states:

> The flight was from west to east and quite marked. As it became darker the quantity of flying anopheles increased, and by looking at a dark object against a clear sky hundred of anopheles could be seen passing by.

The mosquitoes flew from the propagation area in a swamp to Gatun, and some of the breeding places were more than 2 miles from Gatun.

At Mian Mir, James found adult mosquitoes present when no larvæ could be found within 2 and 2¼ miles, and Le Prince[21] determined that *Cellia* (*Anopheles*) *albimanus*, the principal transmitter of malaria in the Canal Zone, will travel against a 4-mile breeze for distances of a mile, and possibly farther.

The confusion regarding the distance of flight of anophelines is undoubtedly partly due to observers studying different species, but while it is probably true that the majority prefer to fly short distances in order to reach their food, it must be recognized that these mosquitoes are capable of flying for two or more miles, and this fact is of great importance in the prophylaxis of malaria. It is more than probable that much longer distances can be covered by interrupted flight, and that the anophelines are not an exception to the rule that mosquitoes will fly for great distances in order to reach their food or their breeding places.

Breeding places.—Contrary to our older notions regarding the breeding places of anophelines we now know that these mosquitoes may breed in practically any collection of water, even though there be quite a current present. Watson[22], in the Federated Malay States, found that *Nyssorhynchus willmori* will breed in mountain streams where the current is swift, and that the larvæ of this species is capable of swimming against the current of these streams. As a rule the anophelines prefer to breed in comparatively clean water, as that found in slowly running streams or in pools of rain water, but they will breed in foul water and have been found in sewers. Paddy fields, storage tanks, wells, ditches, ponds, gutters, drains, and springs are all favorite breeding places of anophelines, some species preferring one place and some another. As Theobald states:

> Practically all kinds of collections of water are acceptable to the larvæ; some prefer rain-water barrels, cisterns, and the water in tins, calabashes, and jam pots; others ponds, slow running streams, and along the banks of large rivers; others live in the water collected in bromelias, and in the water that collects in hollow bamboos, gaining their entrance through exit holes left by boring insects. The domestic species which are best known usually choose barrels and cisterns.

In the Philippines a favorite breeding place of anophelines was the cavity left after cutting off bamboo poles near a joint. In the latter part of the rainy season I have found larvæ in nearly every bamboo pole examined, and at Camp Stotsenburg, where temporary quarters for a large number of troops were built of this material, anophelines became a veritable scourge and malaria increased to such an extent that it was found necessary to remove the larger part of a brigade which had been stationed there.

Among the breeding places of anophelines which are most likely to be overlooked may be mentioned the small depressions in the ground produced by the hoofs of animals or the inequalities left in plowed land. In the tropics, during the rainy season, such breeding places are sometimes very numerous and furnish a considerable proportion of the mosquito population. Another source of mosquitoes generally overlooked is the water that collects at the bases of the leaves of certain plants, especially the *Bromeliaceæ*. Lutz[23] found *Anopheles cruzii* breeding in the water collected by the leaves of these plants and other observers have confirmed his results.

It has also been determined that some species of *Anopheles* will breed in brackish or salt water. Among these species may be mentioned *Anopheles crucians*, *Myzomyia ludlowii*, *Anopheles quadrimacutatus*, *Cellia* (*Anopheles*) *albimanus*, *Cellia* (*Anopheles*) *argyritarsis*, and *Anopheles tarsimaculata*.

From this very brief discussion of the breeding places of the *Anophelinæ* it is evident that in malaria prophylaxis the practical point to remember is that no collection of water, however minute, should be considered as of no importance as a breeding place for these insects. As Smith has well said, the *Anopheles* breed "*everywhere*," and therefore every collection of water should be carefully examined before it is considered free from the larvæ of these insects.

Certain colors in relation to the Anophelinæ.—It is a well known fact to anyone having experience with mosquitoes that they prefer dark to light colors and that a person dressed in black is much more apt to be bitten repeatedly than a person dressed in white. The researches of Nuttall and Shipley [24] have shown that *A. maculipennis* is very partial to certain colors, and this is probably true of other species of anophelines. They found that dark blue was the most attractive color to them and that pale green, light blue, orange, and yellow actually appeared to repel them. They call attention to the khaki uniform as especially suitable because of its lack of attraction for the insects.

Longevity and hibernation.—Our knowledge regarding the longevity of the *Anophelinæ* is still incomplete, but we know that the life of the male is only a few days and that the females of different species vary greatly in length of life, some living for weeks only, while those that hibernate may live for many months.

In temperate climates the winter is passed by most anophelines in the adult stage of development, the females alone hibernating. Although this is so, the anophelines may pass through the winter in the ova or as larvæ. The females that hibernate are fertilized, and only lay their eggs in the spring, although if a warm spell occurs during the winter some of them will emerge from their hiding places and bite, and may thus cause outbreaks of malaria even in the middle of winter.

In the Tropics the adult anophelines hibernate during the hot dry season and lay their eggs at the beginning of the rainy season. As long as the weather is dry very few anophelines will breed in the Tropics, but the beginning of the rainy season is always marked by an immense increase in the number of these mosquitoes, and breeding places are easily found.

During hibernation the adult insects may be found in cellars, outhouses, stables, under the roofs of unceiled habitations, in dark closets, in hollow trees, or under shelving. In these situations they may be found in hundreds, or even thousands, and if disturbed appear sluggish and only fly for short distances.

I have already called attention to the fact that the ova of anophelines will withstand drying for some time, and I am of the opinion that in the Tropics many species would cease to exist were it not for this property, owing to the long dry season and the comparatively small number of hibernating females.

As regards the *number of generations* during a season our knowledge is very incomplete. According to the observations of Kulagin[25] the anophelines have only one generation annually. He calls attention to the fact that the female anopheline does not lay her eggs all at one time and states that, in temperate regions, the egg-laying extends throughout the entire summer, and that the adult mosquitoes derived from these eggs do not lay eggs until the following year. His observations extend over several years and are the most accurate that we possess upon this subject.

Nothing is known regarding this subject in respect to the mosquitoes of the Tropics.

Resting position of adults.—The resting position of adult anophelines and the position assumed when biting, the two being practically identical, offers one of the easiest and most valuable methods of differentiating between them and other mosquitoes. When resting upon a flat surface, as a wall, mosquitoes belonging to the *Anophelinæ*, with few exceptions, form a distinct angle with the surface, the insect resting upon the first two pairs of legs, the last pair floating in the air or held out straight behind it. The angle formed by the body of the mosquito and the surface varies, but sometimes is nearly a right angle. The only exceptions to this rule among the anophelines commonly observed is *Myzomyia* (*Anopheles*) *culicifacies*, which rests upon a surface in the same position as a *Culex* mosquito, and *Pyretophorus* (*Anopheles*) *superpictus* and *Myzomyia* (*Anopheles*) *hispaniola*, which assume a perpendicular position in reference to the wall.

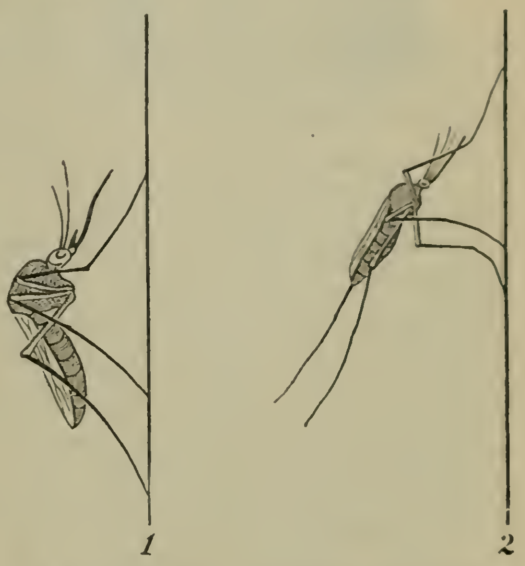


FIG. 3.—Comparison of resting position of *Anopheles* and *Culex*. 1, resting position of *Culex*, on vertical surface; 2, resting position of *Anopheles* on vertical surface. (The resting position upon a horizontal surface may be observed by turning the page so that the vertical line becomes horizontal.)

The position assumed by other mosquitoes, as *Culex*, *Stegomyia*, etc., is well described as "humpbacked," the abdomen approaching the resting surface while the thorax is distinctly higher than any other portion of the body, thus giving the humped appearance.

Whatever the position of a mosquito, it can always be determined whether it is an anopheline by attention to the relative position of the proboscis to the body. In the *Anophelinæ* the proboscis is always in a direct line with the rest of the body when the insect is resting upon a surface, while in all other mosquitoes the proboscis forms an angle with the abdomen. This peculiarity is easily recognized and gives the anopheline a distinctly "business-like" appearance, the entire body of the insect resembling a boring instrument.

Practical points in the differentiation of the Anophelinæ.—The following practical points may prove of use in the differentiation of anophelines from other mosquitoes in their various stages of development:

1. *The ova.*—The ova of the *Anophelinæ* are never found in masses, but are laid single upon the surface of the water, the ends often being connected, thus forming geometrical patterns. They are further distinguished by the possession of lateral "floats," which never appear on the ova of other mosquitoes.

2. *The larvæ.*—The larvæ of the *Anophelinæ* are easily distinguished from those of other mosquitoes by the absence of the long respiratory tube or siphon. Because of this the anopheline larva is compelled to lie parallel with the surface of the water, while other mosquito larvæ hang head downward at an acute angle with the surface of the water. In addition the small, narrow head of the anopheline larva distinguishes it from other mosquito larvæ.

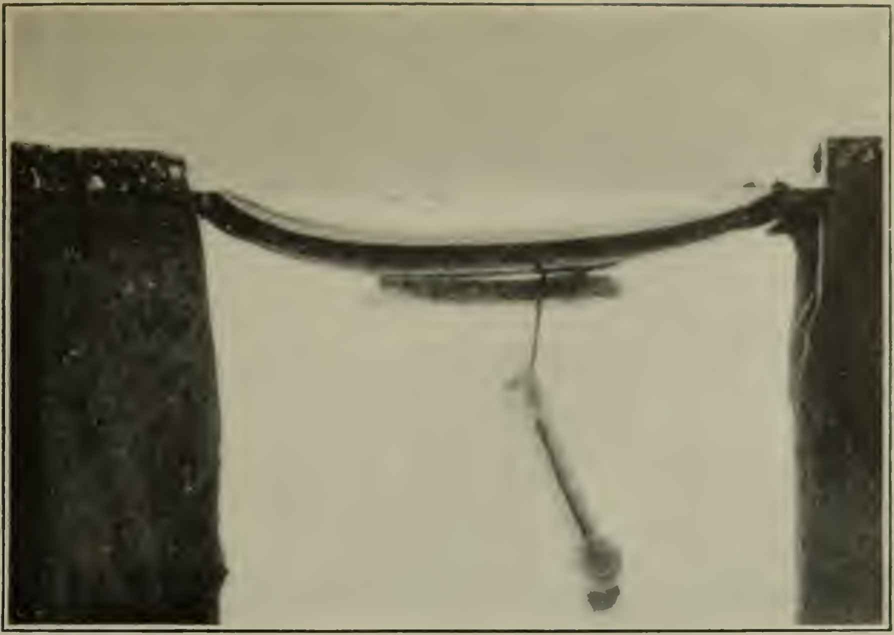
3. *The imago or adult.*—The following points distinguish the adult anopheline from other adult mosquitoes:

a. The relative length of the palpi and the proboscis.—In the *Anophelinæ* the palpi of the female are as long as the proboscis, while in other mosquitoes the palpi are much shorter than the proboscis. The males are distinguished from the females by their plumose palpi. By attention to this simple detail any mosquito may at once be placed so far as its relation to the *Anophelinæ* is concerned.

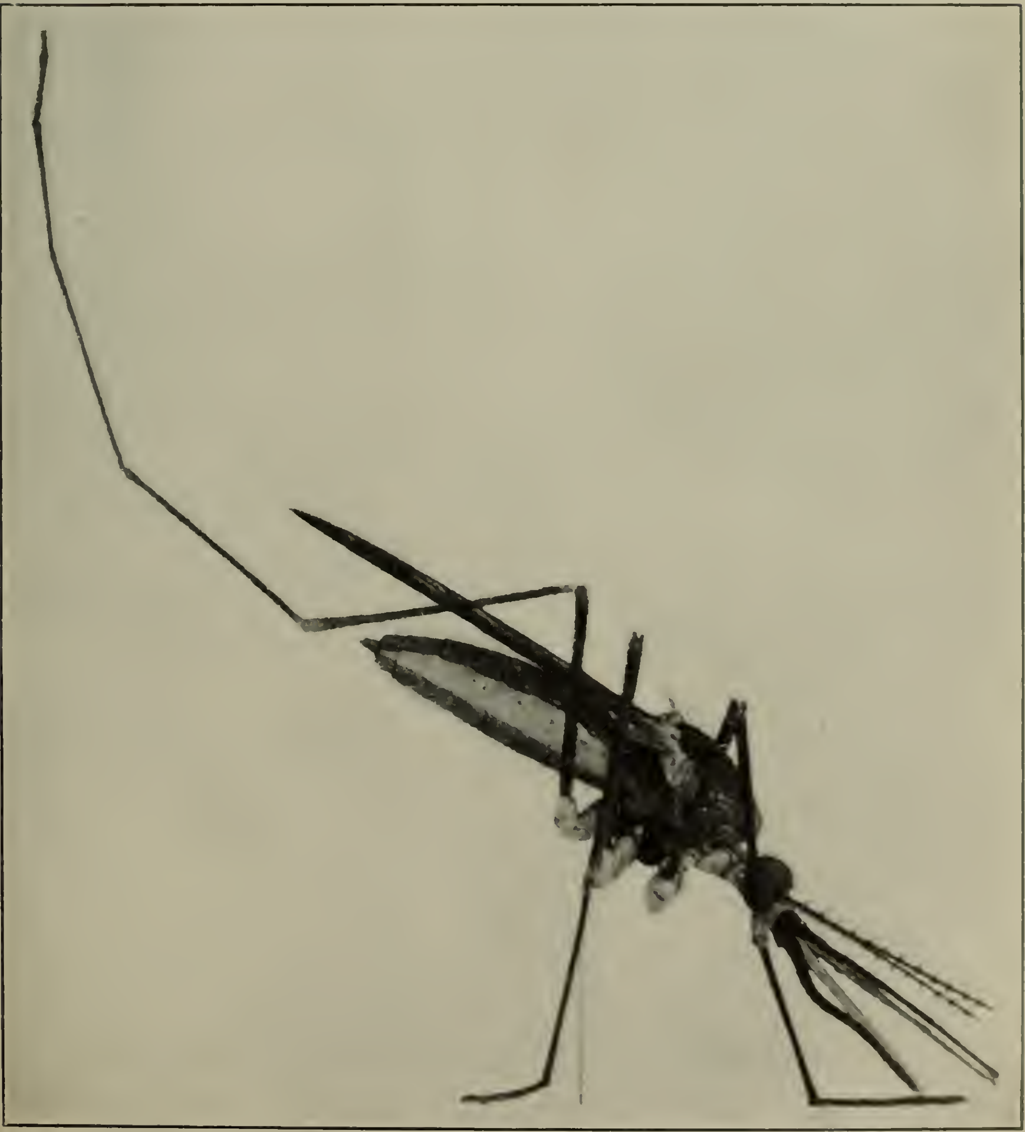
b. The angle of the proboscis with the body.—The proboscis in the anophelines never forms an angle with the rest of the body but continues in a direct line with it, as already stated.

c. The resting position.—When resting upon a surface most of the *Anophelinæ* form a distinct angle with the surface, while other mosquitoes appear humpbacked owing to the fact that the abdomen is nearer the surface than the thorax.

d. The spotted wings.—Most of the *Anophelinæ* have spotted wings and while some other mosquitoes also present spots upon these structures it is a good practical rule to always regard with suspicion any mosquito having spotted wings, as the chances are altogether in favor of its being an anopheline.



ANOPHELES AND CULEX LARVÆ IN NATURAL POSITION IN WATER. (HOWARD.)



FEMALE ANOPHELES IN CHARACTERISTIC STINGING POSTURE.

Photograph of the model (X 75) in the American Museum. Magnification of figure about 10 diameters.

METHODS OF COLLECTING AND DISSECTING MOSQUITOES.

The following directions for the collection and dissection of anophelines are all that are necessary for one engaged in practical prophylactic work. No attempt is made to describe methods of breeding the insects or of experimentation, as these phases of the subject relate more distinctly to the laboratory than to work in the field.

Collection.—The *ova* of the *Anophelinæ* may be collected from the breeding places with a white agate ware dipper, but it should be remembered that they are very inconspicuous and have to be searched for very carefully.

The *larvæ* may be collected in a dipper from the breeding places by slightly muddying the water of puddles or shallow streams when they are more easily observed by reason of their grayish color. In small receptacles, water barrels, etc., they can easily be collected with the dipper. The *adult* insects are easily captured by the use of a collecting tube. At night they may be attracted by placing a lamp in such a position that a portion of the wall is but slightly lighted, when it will be found that the mosquitoes gather at the junction of the shaded area and can be easily captured. For this purpose a large test tube or a small straight glass cylinder may be used, the open end being placed over the mosquito as it rests upon the wall, then slightly moved across the surface of the wall, when the insect will fly to the closed end, whereupon the open end is removed quickly from the wall and plugged with cotton. If it is desired to kill the insects a small amount of cotton saturated with chloroform is placed at the bottom of the tube and covered with a disk of perforated cardboard, after which the tube is used as described. The utmost care should be used to avoid breaking the wings or otherwise injuring the insects if they are to be sent away for identification.

As the identification of the species of mosquitoes in any region may be a matter of great military importance, every effort should be made by medical officers to have the species identified in the localities in which they are serving. For this purpose the chloroform killing tube should be used to capture the mosquitoes, after which they are carefully slid from the tube into a small box containing absorbent cotton. Great care should be taken to avoid touching the insects or allowing the chloroform in the killing tube to come in contact with them. Not more than three or four mosquitoes should be placed in a box, and a label should be pasted upon the cover giving the place, date, and hour of collection, and any other data that is thought useful. If the box is to be mailed it should be inclosed in a larger box and packed carefully in cotton.

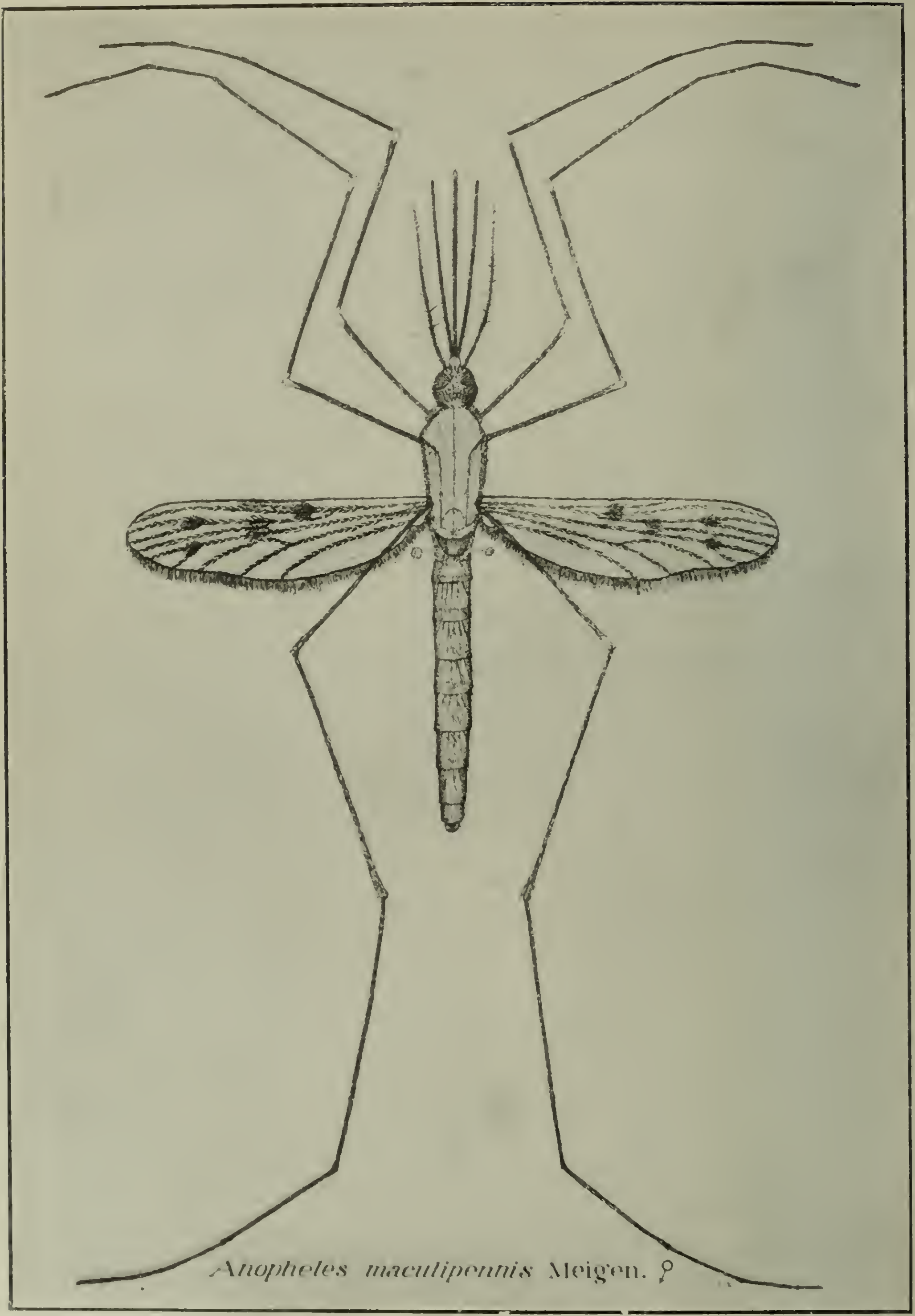
The dissection of mosquitoes.—To many the thought of dissecting a mosquito conjures up an amazing amount of difficulty, largely owing to the small size of the object to be dissected. As a matter of fact anyone possessing the most rudimentary knowledge of laboratory technique should have no trouble in dissecting these insects and demonstrating the presence or absence of malarial infection in them after having once been shown the really simple technique.

In order to make good dissections the following apparatus is necessary: Microscopic slides and cover glasses, fine dissecting needles, a good dissecting microscope, and some normal salt solution. A compound microscope, of course, is necessary for studying the development of the malaria plasmodia, but malarial infection of the mosquito may be demonstrated, in many instances, with the high powers of the dissecting microscope. The parts of the mosquito of special interest to one engaged in the prophylaxis of malaria are the salivary glands and the portion of the mid-gut of the mosquito known as the stomach.

Dissection of the salivary glands.—To make a perfect dissection of the salivary glands of the mosquito requires considerable skill, but it is comparatively easy to secure portions of the glands sufficiently perfect to allow of demonstrating the *sporozoites.*

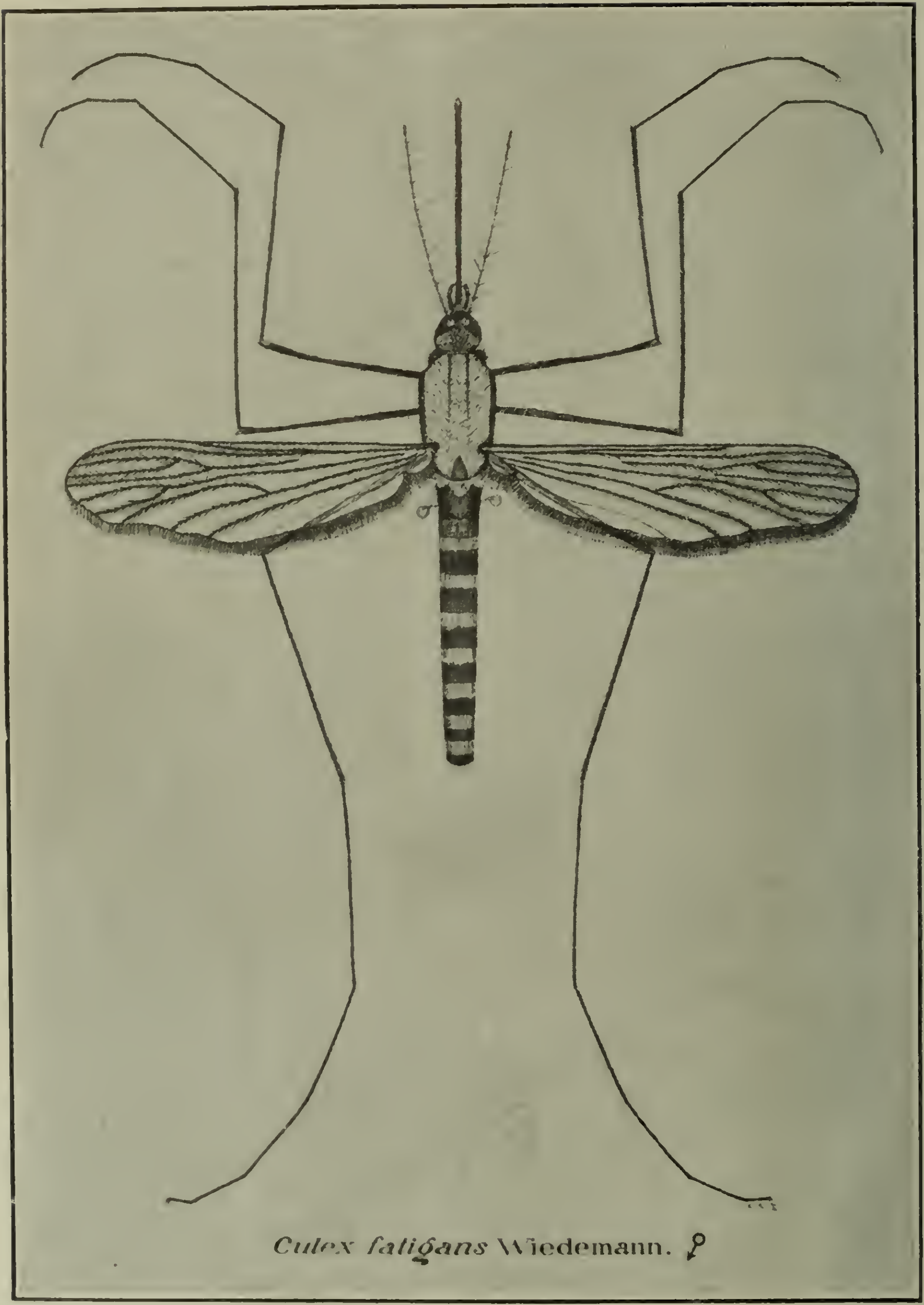
The salivary glands are situated within the thorax, lying ventrally, commencing at the posterior portion of the neck and ending at the level of the first pair of legs. The simplest way of securing them for examination is to cover the insect with salt solution and place it upon the stage of the dissecting microscope in such a position that the head is toward the dissector's hand. Then, with the needle in the left hand steadying the thorax, the chitinous covering of the thorax just back of the neck is incised, and then gentle traction is made with the needle in the right hand upon the head, separating it gently from the body. If the operation has been successful it will be noted that a minute bit of white tissue has been extracted with the head, and upon examination with the compound microscope it will be observed that in this bit of tissue lie the salivary glands, or portions of them. This tissue should now be removed from the head with a fine needle and placed upon a microscopic slide in a drop of normal saline.

In order to determine the presence of malaria *sporozoites* the preparation should be covered with a cover glass, gentle pressure applied, and examined with a one-sixth inch or one-twelfth inch objective. If *sporozoites* are present they will appear as fine, hyalin, curved rods, lying within the cells or ducts of the gland or free in the salt solution in great numbers. They often occur in masses or side by side and measure about 14 micros in length.



TYPICAL ANOPHELINE MOSQUITO.

Note long palpi and spotted wings. (Ludlow.)



TYPICAL CULICINE MOSQUITO.

Note short palpi and unspotted wings. (Ludlow.)

Dissection of the "stomach" of the mosquito.—To dissect that portion of the mid-gut of the mosquito, known as the "stomach," the following procedure is recommended:

The insect, from which the wings and legs have been removed by scissors, is moistened with a little alcohol or salt solution and then placed back downward upon the glass stage of the dissecting microscope or upon a glass slide placed upon the stage. Using a needle in the left hand to steady the insect, a nick is made in the chitin of the thorax on either side as near the posterior end as possible: the left needle is now placed firmly upon the thorax and the right upon the last abdominal segment, and gentle traction exerted by the right hand, when between the separating segments a white mass of viscera is observed which contains the mid-gut, hind-gut, Malpighian tubules, and ovaries, or may contain only a portion of these. The mid-gut is separated, and will be found to consist of an anterior tubular portion and a posterior sacular portion, which is the so-called "stomach" of the mosquito and which contains the malarial cysts or *zygotes* if they be present. This portion of the mid-gut is placed upon a slide and examined with a one-sixth lens; but if it contains blood it should be discarded, as in this case the *zygotes* are apt to be overlooked.

If the fully developed cysts are present, they may be seen with the one-sixth lens projecting from the wall of the stomach or apparently embedded in the wall. They may often be picked up quickly by attention to the presence of pigment, for some of them contain a small amount of melanin. The earliest stage observed is an oval or spherical body about 8 microns in diameter and containing more or less pigment, which may or may not be motile. As the *zygotes* increase in size, a well-defined capsule or cyst wall develops, and when the *sporozoites* have developed they may be seen packing the cysts, which have become so large that they may be observed with a one-third-inch lens. The pigment decreases in amount as the *zygotes* develop, and when they are fully developed many of them are entirely devoid of pigment.

For a more minute description of the technique of the examination of mosquitoes and of the morphology of the malaria plasmodia within the mosquito, the reader is referred to any of the larger works upon the malarial fevers which are given in the list of references in this bulletin.

CHAPTER III.

PROPHYLACTIC METHODS BASED UPON THE DESTRUCTION OF MALARIA MOSQUITOES.

In the prophylaxis of the malarial infections the following measures have been found efficient in practice: 1. The destruction of the mosquitoes transmitting the infection; 2. The protection of man from the bite of mosquitoes; 3. The destruction of the malaria plasmodia while in the blood of man. Theoretically, any one of these methods would be sufficient to prevent malarial disease could it be applied in an ideal manner, but practically, it is but seldom that one is successful without the aid of the others, and it is generally necessary to combine them all in order to achieve the fullest success in the prevention of malaria in any locality.

In this chapter will be considered those methods of malaria prophylaxis that depend for their success upon the destruction of the mosquitoes transmitting the disease, and in applying these methods it is necessary that one have knowledge of the life history of the *Anophelinæ* to the extent comprised in the data given in the preceding chapter. It is obvious that before applying most of the methods mentioned in this chapter it will be necessary to make a mosquito survey of the locality one is working in, thus determining whether malaria mosquitoes are present or not, their breeding places, and the preventive methods most applicable and economical for the region investigated.

The prophylaxis of malaria by the destruction of mosquitoes is the *ideal method of prophylaxis* where conditions are such as to render the destruction of these insects practicable, but in the military service such methods must necessarily be restricted to more or less permanent camps or to permanent posts, as most of them are impracticable upon the march or in camps of short duration. In many regions in the United States where military posts are located it is believed that the malaria present could be entirely eradicated by the adoption of methods looking to the destruction of mosquitoes, and this may also be true of isolated instances in our tropical possessions, but in most regions, especially in the Tropics, the most that we can hope to accomplish in the way of mosquito destruction is to greatly reduce the number of the insects, and in such localities other methods of prophylaxis must be used in conjunction with the destruction of the mosquito.

The malaria mosquitoes may be destroyed at any stage in their development, but most of the prophylactic methods depend for success upon the destruction of the insect during the larval and adult stage, the larvæ being destroyed by the abolition of the collections of water in which they have developed or by larvacides, and the adult insects by various chemical agents or other measures. The most important measures consist in the abolition of the breeding places of the mosquitoes by leveling, drainage, and clearing, and if they can be carried out in an efficient manner they are the most valuable that we possess, and in the vast majority of instances are capable of geatly reducing, if not almost eradicating, malarial disease. Unfortunately, the terrain often renders the application of these measures very expensive and other prophylactic methods are substituted, but, where it is possible, I believe that these measures, although the first cost may be great, should be the ones adopted, as they produce permanent results and in the case of many of our Army posts would banish malaria from the sick report.

Drainage.—If possible all large breeding places of mosquitoes should be drained, if they can not be filled in or otherwise abolished. If filling in is feasible, this is the better method, but the relative cost of the two methods must be considered for each locality and the choice made as to which will be the cheaper and most efficient.

If drainage is decided upon, the question arises as to the particular kind of drainage to be used. In many temperate and subtropical regions open ditches may be used, provided the edges are kept free from plants and algæ and there be enough slope to give a comparatively swift current. Otherwise, the open ditch, although it may drain a larger body of water, simply becomes a mosquito breedery, and this is almost sure to happen in the Tropics, where it is practically impossible to prevent the growth of plants and algæ in the water of the ditch. This fact has been well brought out by Le Prince [26], who says:

> On the Isthmus and probably throughout the Tropics, under average conditions, we could not consider such a mode of procedure (the open drainage ditch) as it would give most unsatisfactory results. Such a ditch would become a veritable Mecca for anopheles.

In order to prevent the development of vegetation in the ditch it would have to be cleaned out in the Tropics on an average of once a week, and this alone would make their use practically impossible, as the cost of labor and upkeep would be too great unless the ditches were few in number and of limited extent.

The blind drain.—Le Prince,[27] the chief sanitary inspector of the Isthmian Commission in 1908, recommends this method of drainage in case tile drains can not be obtained. He defines a blind drain "as a miniature culvert covered with field stones," and states that they give fairly good results. Such drains are constructed as follows: A ditch is dug and the bottom covered with flat stones, the sides are formed by a layer of flat stones, and a cover stone is placed on top, after which the whole is covered with quite large stones and lastly with small stones. Regarding this type of drain Le Prince says:

> Where plenty of stone is available and must be removed from a field, this form of ditch is economical to make and, in the Tropics, much more economical to maintain than an open ditch is, while anopheles larvæ do not occur therein * * *. We opened some of these drains when the flow of water in them was sluggish, but found no mosquito larvæ therein. The advantage of this type of drain is that there is no first cost for material, the field stones are disposed of, and there is no cost of maintenance except when the ditch clogs up. A good grade is essential for blind drains, and they will stand on a fairly heavy grade.

The cement-lined open drain.—This is the only form of open drain that should be adopted in the Tropics, and it should always be laid upon a considerable grade. Such drains should be semicircular in shape and constructed of stone or brick, lined with cement. If laid upon a good grade such drains will keep themselves clean by the flushing of the water and will not become filled with vegetation and algæ.

Subsoil drainage with tiles.—Le Prince says that "the use of tile drainage is the most economical and permanent method of destroying anopheles in the Tropics. The work costs from 16 to 20 cents a foot upward, according to the depth of the trench, material to be excavated, and distance that the tile and covering stone has to be carried." He recommends that the tile drains should not be given a flatter grade than 0.5 per cent, and states that those having as high a grade as 5 per cent gave perfect satisfaction if the tiles be covered with plenty of stone to hold them in place. This is the method of drainage adopted in the Canal Zone, where it has proven less expensive in the end than the open ditch and much more efficient.

The question of the prevention of mosquitoes by drainage is a purely economical one, as there is no question of its efficiency in any region where it can be applied. In the Tropics its application is much more difficult than in temperate regions, but the success of this prophylactic method in the Canal Zone proves that even in the Tropics it can be used under the most difficult conditions and that its use is both economical and successful. In many of our posts a system of tile drainage would completely eradicate mosquitoes at a much less final cost than is now expended in screening and for mosquito nets.

Filling.—In many localities the filling in of low ground and of small pools will serve to destroy most of the breeding places of mosquitoes, and this is often a very valuable prophylactic method.

Removal of shelter.—In conjunction with drainage and filling in of the breeding places of mosquitoes, the removal of brush along the banks of streams and of vegetation and algæ in the streams or of any shelter for the mosquitoes, such as is furnished by jungle long grass about residences, and vines and bushes, is a valuable prophylactic measure. The removal of the vines so often observed inclosing the porches of barracks and quarters in some of our most malarious posts should be insisted upon if mosquitoes can not be eradicated, as they furnish shelter to many of these insects, and their removal will result in a great diminution in the number of mosquitoes and, consequently, in the prevalence of malaria. The same is true of all shrubbery about habitations, and the measure adopted in the Canal Zone of removing all such vegetation for 200 yards around the houses could be followed with excellent results in more than one of our Army posts.

The clearing of rank vegetation and jungle for several hundred yards around a camp or post is not only useful because it deprives the mosquito of shelter, but it also results in the discovery of the small breeding places of the mosquitoes which could not otherwise be seen. The anopheline mosquito does not require a lake to breed in but, as has already been stated, will breed in the smallest depressions in the ground that will hold water, and every clearing operation, especially in the tropics, always results in the discovery of many of these minute breeding places.

At Camp Stotsenburg, in the Philippines, it was invariably noted that mosquitoes increased greatly in number whenever the grass about the post was allowed to grow to any great length and that a coincident increase occurred in the number of malarial cases admitted to hospital. At one time, owing to lack of facilities for cutting, the grass was allowed to grow for several weeks, and the mosquitoes became so numerous as to be almost unbearable, while the number of cases of malaria admitted to the hospital became alarming. As soon as the grass was mowed the mosquitoes decreased in number, as did the number of malarial infections, thus conclusively proving the danger of affording shelter to the mosquito.

Destruction of mosquito larvæ with larvacides.—While the drainage or filling in of the larger bodies of water that are breeding places for mosquitoes is the ideal method of dealing with them, it frequently happens that this is impossible owing to various local conditions. When this is the case the larvæ may be killed by certain substances which may be added to the water, and this furnishes us with a prophylactic method of considerable value.

Many substances have been recommended for this purpose, the most important of which will now be considered:

Petroleum.—The use of kerosene as a larvacide was first recommended by L. O. Howard,[28] and it has been used very largely by the

Army, both in this country and in Cuba and the Philippines, with excellent results. This method of prophylaxis depends for success upon the fact that the larvæ of mosquitoes are unable to breathe if the surface of the water is covered with a film of oil, and it therefore follows, that in selecting petroleum for this purpose an oil should be chosen that will spread rapidly when placed upon the surface of water and one that will not evaporate too rapidly. Howard recommended to the Army in Cuba the use of the grade of oil known as light fuel oil, costing from $2.25 to $3 per barrel, and this was used with good results. A thicker oil, composed of 4 parts of oil of 18° gravity and 1 part of oil of 34° gravity, is recommended by Quale, who used it in California and found that it remained efficient for from three to four weeks after application.

The application of the oil, in the case of large bodies of water, is best made with a pump having a straight nozzle. The operator is rowed from side to side of the pond and the oil discharged at such intervals that when it rises and spreads the entire surface passed over is covered. In smaller collections of water an ordinary watering pot may be used with a spray nozzle or the oil may be poured from a cup or dipper. The greatest care should be taken to see that there are no portions of the surface left uncovered after the oil has spread, and all oiled collections of water should be inspected at least every third or fourth day, as the layer of oil becomes easily displaced by currents in the water, by winds, or by the movements of aquatic animals. Whenever unoiled areas appear upon the surface the oiling of that particular portion of the pond should be repeated. In the case of more or less stagnant streams or ditches the oil is best applied with a pump and the application frequently repeated. The pumps used for this purpose are the ordinary knapsack pump or the bucket pump.

The exact time that the oil will have to be renewed varies greatly, and in many instances the method is rendered almost useless by ignorance regarding the necessity of renewing the oil at frequent intervals. While, in rare instances, one application of oil may be efficacious for as long a period as four weeks, in the vast majority of cases the application will have to be renewed much within that time. Where the temperature is high and the surface of the water is exposed to the sun, the oil evaporates rather rapidly and has to be renewed at much shorter intervals than where the temperature is low and the collection of water is well shaded.

It would seem that the most sensible rule for renewing the oil would be to reoil every two weeks. We know that the average life of the larvæ of mosquitoes is from 10 to 14 days, and if the oil be reapplied at these intervals we will be sure to destroy the vast majority of the larvæ. However, if inspection of the oiled water shows that the oil has in part or wholly disappeared before the end of two weeks, it is obvious that reoiling should be done at once. The two-week interval was the time adopted by the Army medical officers in Cuba and was found to give satisfaction.

In some regions the use of oil as a larvacide is practically impossible owing to the currents produced by the strong winds of the locality or to the development of tropical vegetation in the collections of water to be oiled, thus preventing the spreading of the oil over the water surface. In such instances the use of a larvacide that is less easily displaced by winds and that is capable, to some extent, of killing vegetation is indicated, but up to the present time such an ideal larvacide has not been discovered, the nearest approach to it being the one used in the Canal Zone and which will now be described:

The Canal Zone larvacide.—This preparation has been very largely used in the Canal Zone, and all of the reports concerning its action are very satisfactory. Darling[23] has described the method of manufacture and has conducted valuable experiments determining its efficiency when brought in contact with the larvæ of both *Culex* and *Anopheles* mosquitoes. He thus describes the method of preparing the larvacide:

> One hundred fifty gallons of crude carbolic acid (specific gravity not greater than 0.97 and to contain not less than 30 per cent tar acids) are heated in an iron tank having a steam coil with steam at 50 pounds pressure. Two hundred pounds of finely crushed and sifted common rosin are dissolved in the heated acid, and then 30 pounds of caustic soda, dissolved in 6 gallons of water, are added. There is a mechanical stirring rod attached to the tank. The product is ready in a few minutes, yielding about 3½ barrels.

Regarding the value of this preparation as a larvacide, he says:

> The resultant emulsion makes a very good disinfectant or larvacide. In fact, 1 part of it to 10,000 parts of water will kill anopheles larvæ in less than half an hour, and 1 part to 5,000 parts of water will kill anopheles larvæ in from 5 to 10 minutes or less. This property of killing larvæ rapidly is of great importance in the Tropics, where continuous rainy periods make crude oil or kerosene much less valuable as a larvacide than it is in northern latitudes having less rainfall. Also the larvacide acts as an algecide, and thus destroys the food and hiding places of anopheles larvæ.

This larvacide is used by spraying an emulsion, prepared by adding 1 part of the larvacide to 5 parts of water, over the surface and along the edges of ponds, streams, or other collections of water that serve as breeding places for mosquitoes.

Used in this manner the larvacide will kill all anopheles larvæ within five minutes, and it possesses the advantage that after a few hours, in case of running streams, the water will be again fit for domestic use.

This larvacide would appear to be an ideal one for adoption by the Army in its antimosquito work, especially in the Tropics where the use of kerosene is expensive and often inefficient. The cost of preparing it is stated by Darling to have been but $0.1413 per gallon, which is very much less than any fuel oil can be purchased for, and 1 gallon of the larvacide makes 6 gallons of the preparation when diluted with water for use in the spray. In addition this larvacide is a good germicide, having a Rideal-Walker coefficient of from 2 to 5. One, or at most two, larvacide plants could supply all the larvacide needed in the Philippines, and the same is true of the United States, and the manufacture and use of this substance by the Government would result in a considerable reduction in the cost of malaria prophylaxis and at the same time furnish the Army with a more efficient larvacide than kerosene oil.

Other larvacides.—Among other substances that have been recommended as larvacides may be mentioned permanganate of potassium, sulphate of copper, corn oil, Phinotas oil, and many proprietary preparations. None of these are as efficient as the larvacides already mentioned, and the only one that has been used extensively is Phinotas oil, which has been used to a considerable extent upon the Isthmus of Panama. It is capable of quickly killing the larvæ, but also kills fish, so that it should not be used where it is desired to preserve the latter.

Although it is possible to secure very excellent results in the prophylaxis of malaria by the use of larvacides the method is always an admission that we are unable to control mosquito breeding by the much better one of abolishing the breeding places of these insects, and it should never be adopted in preference to the latter. Under the best conditions it is imperfect and the results are not to be compared with those obtained by drainage or filling in of breeding places. In addition, especially in the Tropics, the method is more expensive, because the results are not permanent, the use of the oil having to be continued for months, while, even in temperate regions, it is doubtful if this method is as economical as the abolition of the breeding places. It finds its greatest field of usefulness in those instances where breeding places can not be abolished owing to the expense involved, or where open ditches and streams can not otherwise be prevented from becoming breeding places of these insects.

Destruction of larvæ by fish.—The well-known fact that several species of fish are voracious devourers of mosquito larvæ has been taken advantage of in the prophylaxis of malaria, and there are many accounts in the literature of attempts to render the breeding places of mosquitos harmless by the introduction of fish that will devour the larvæ. There is no question that in many instances these attempts have met with a considerable amount of success but, as a rule, the results have been disappointing. The fish that are the most useful are the roach, carp, top minnows, and the goldfish, the roach and top minnows especially being very active in devouring the larvæ. Where there are small ponds or artificial collections of water of limited extent the stocking of them with these fish will often result in keeping them comparatively free from mosquito larvæ, but the method, at best, is a very imperfect one, and possesses little of value for the military sanitarian, although, in very exceptional cases, it might yield good results.

The abolition of breeding places in and about quarters and barracks.—It has already been stated that anopheline mosquitoes will breed in even the smallest collections of water and that, with several species, it makes no difference what the quality of the water may be. The old idea that the *Anopheles* will only breed in clean water and only in streams or larger collections of water has long ago been abandoned, and we now know that they will breed both within and without quarters and barracks wherever a collection of water forms large enough to contain the mosquito eggs. This renders the sanitation of quarters and barracks of the very greatest importance in any campaign against malaria in a military post, and it is remarkable how many breeding places may be discovered around and in quarters and barracks that are believed to be perfectly free from them. Among the breeding places that occur in the quarters and barracks may be mentioned uncovered fire buckets, stopped drains, the unused hoppers in toilets, unscreened water tanks, earthenware vessels containing water, tubs, water traps that are not flushed out frequently, and the cans of water that are often used in the Tropics to place table legs in to prevent ants from getting to the food. All of these are favorite breeding places of certain species of *Anopheles* and are very frequently overlooked by those having little knowledge of the habits of these mosquitoes.

If the post is in the neighborhood of native quarters, as generally happens in the Philippines and our other tropical possessions, the condition of these quarters as regards the breeding of mosquitoes becomes of paramount importance and necessitates the greatest care in inspecting and abolishing the numerous breeding places that are always present around and in native houses. An inspection of the premises will generally reveal larvæ in the water that has collected in broken bottles, old culinary utensils, tin cans, tin-lined boxes, water barrels, and chicken troughs. In addition, puddles of water will often be found teeming with larva in the immediate vicinity of the dwellings, and even the bamboo fence that surrounds so many native houses will be found to breed numberless mosquitoes in the cavities left by cutting off the bamboo near a joint or where the mosquitoes have gained entrance through holes made by boring insects.

The discovery of these small breeding places of mosquitoes and their proper treatment forms one of the most important duties of sanitary officers in localities where malaria is endemic, and the ability to make a really scientific mosquito survey of a post and its surroundings should be considered one of the most valuable of all possessions to one who is engaged in the prevention of this disease.

All receptacles in which mosquitoes may breed and which are not needed in domestic operations should be removed or destroyed, and those in which it is necessary to keep water should either be frequently emptied, screened, or oiled. Barrels or tubs for the collection of rain water, as well as cisterns, should be covered with well-fitted screen covers, made of wire containing not less than 18 meshes to the inch. Unused hoppers of toilets and water traps should be flushed thoroughly at least once a week, and drains should be frequently inspected and flushed. One of the most common sources of mosquitoes connected with barracks and quarters are clogged roof gutters, and I have frequently found such a gutter alive with larvæ after heavy rains that had left the gutter full, followed by enough light rain to prevent total evaporation of the water. The inspection of all roof gutters and their repair, where clogged, is an important prophylactic measure in Army posts.

The fire buckets found in most barracks are prolific sources of mosquitoes unless they are properly looked after. All that is necessary in order to prevent the development of larvæ is to see that they are emptied each week and filled with fresh water. As the average life of the larvæ is about 14 days, one is perfectly safe if the buckets are emptied each week. If desired, wire screen covers may be used, but these are expensive and unnecessary if the buckets be properly emptied and refilled at weekly intervals. The oiling of the water in fire buckets, so frequently observed, is an evidence of the lack of knowledge of the life history of mosquitoes on the part of the officer ordering such a procedure, and certainly the addition of oil to water destined to extinguish fire does not improve its value in that direction. The buckets should not be emptied into the sewer, but upon the ground in direct sunlight where the water will quickly evaporate and the sun kill any larvæ that may be present.

Water troughs for domestic animals should be flushed frequently, and in no case should the water be allowed to remain if the trough is not in use. The tanks in water-closets, the sewer traps of the post, and open cesspools, if present, should be frequently inspected and properly treated, the tanks and sewer traps by flushing or oiling and the cesspools by oiling at intervals of two weeks.

The best way to accomplish the abolition of the small breeding places mentioned is to place the work under the charge of a sanitary officer, who should be assisted by a good sergeant and the requisite number of men. If the post is a small one the work can be easily accomplished by a sergeant and one or two men, but if the area to be covered is large and the buildings are numerous the post should be divided into districts, each district being looked after by one man, under the supervision of the sanitary officer and the sergeant. Where native barrios or villages have to be sanitated it will be necessary, of course, to increase the number of men, but the same general plan of organization should be followed.

Destruction of the adult mosquito.—The adult mosquito may be destroyed by various chemicals or they may be caught in mosquito traps or by hand. In the military service the methods of destroying adult mosquitoes that can be adopted are in general too uncertain to be of much value except in fumigating quarters that are to be occupied by troops in countries where malaria is endemic or upon transports plying between malarial and nonmalarial localities. In the field the adult mosquito is most easily avoided by methods which prevent biting and which are much more practical in application than attempts to destroy the insects, although smudges, hereafter described, may prove useful in isolated instances.

A large number of chemicals have been recommended for the destruction of adult anophelines, the most important of which will be briefly discussed.

Sulphur dioxide.—Where it is desired to kill the mosquitoes in quarters or barracks, in transports or other vessels used for military purposes, or in habitations in malarial localities, sulphur dioxide is the most valuable agent that we possess. The success attending its use in Cuba, Panama, and in Rio de Janeiro in the fumigation of houses, and, indeed, whole blocks of houses, as at Santiago, against the yellow-fever mosquito, is familiar to all sanitarians, and the same methods used against yellow fever should be employed in the case of malaria where the disease is of pernicious type and rapidly spreading among troops in quarters.

In employing this agent it should be remembered that it injures most metallic substances and fabrics, and these should be removed before fumigation is begun. The methods of fumigation with sulphur are well known to all sanitary officers of the Army and will not be detailed here. A good rule for determining the amount of sulphur necessary to destroy the mosquitoes in fumigation upon a large scale is to divide the number of cubic feet in each room of the building by 500 and reading the result in pounds. Thus, a room 40 feet long, 20 feet wide, and 12 feet high would contain 9,600 cubic feet, and this divided by 500 would give 19.2 pounds of sulphur for such a room.

In the case of malaria it is evident that only in rare instances would this method of prophylaxis be used in the military service.

owing to the fact that other and more easily applied methods would render it unnecessary. However, there is no doubt of its great value in the prevention of the transmission of yellow fever and in great epidemics of malaria, such as have occurred among troops in quarters, it would undoubtedly be of equal value.

Smudges.—In the field many adult mosquitoes could be destroyed by fires made of material producing a dense smoke, as green vegetation or bark. The American Indian used this method of rendering his tent inhabitable and all hunters are familiar with this device, which might prove very useful to an army in the field in regions where mosquitoes were very numerous and mosquito nets unobtainable.

Pyrethrum powder.—Pyrethrum powder is made from the dried flower heads of plants belonging to the genus *Chrysanthemum*, growing in Transcaucasia. The powder is more commonly known as Persian or Dalmatian insect powder, and depends for its efficiency on the presence of certain oleoresins in the dried flowers, so that to be efficient the powder must be comparatively fresh. The best preparation for use in this country is made in California and is marketed under the proprietary name of "buhach" powder.

For the purpose of destroying mosquitoes the powder is burned in a room, being placed upon a dish or tin and a match touched to it, when it will burn slowly and give off a large volume of smoke having a peculiar odor; or the powder may be procured in the form of cones or pastilles and these burned. The smoke is not harmful or very unpleasant to most people, and if the powder be burned in a closed room it will stupify all mosquitoes in the room and they may be swept from the floor and destroyed. The use of this powder in the rooms of quarters infested with mosquitoes might be of benefit where other measures could not be taken to get rid of them, but from a military standpoint this method of destroying mosquitoes possesses little value.

Numerous other fumigants have been recommended for destroying adult mosquitoes, as camphor phenol or Mimm's Culicide, Pyrofume, mercuric chloride, powdered stramonium, and formaldehyde gas, but none of them are of any importance in the prophylaxis of malaria in the military service and will not be discussed.

Mosquito catching as a prophylactic method.—The catching of adult mosquitoes, first advocated by Orenstein,[30] in the Canal Zone, is really deserving of much greater consideration as a prophylactic method than it has received. It is a method that could readily be adopted in the military service and, under certain conditions, would be a most valuable one, especially in temporary camps in the Tropics. In his paper, published in 1913, Orenstein states that this method has been extensively employed in the Panama Canal Zone and that it has given very excellent results. He quotes two instances given by Le Prince, which are so striking that I will give them in his own words. He says:

> The first systematic application of mosquito catching within habitations as a prophylactic measure against malaria, in so far as I have been able to learn, was made in the Canal Zone, in April, 1908, at a camp near Cocoli. The camp, composed of unscreened tents, was to be maintained only about five months, and it was not thought practicable to incur the great expenditure involved in a thorough antimalarial campaign. When the camp was first established, as many as 30 anophelines could be seen in a tent in the daytime, and many more after dark. One man was employed to kill the mosquitoes in these tents. He worked from 6 to 11 in the morning and from 1 to 5 in the afternoon. In the four and a half months of this camp's existence the malaria incidence was a little over 1 per cent per week.
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> Another remarkable instance is described by Le Prince in Ross's "The Prevention of Malaria." In June, 1908, several hundred United States marines were quartered for about eight weeks on a hill near Panama, known as Diablo Hill. During this period the malaria incidence among the marines was 14 per cent per week. In May, 1909, some living cars were located on the same hill. The anopheline breeding was just as it has been at the time the marines camped there. From the first week in May to the end of November, in the rainy season, when malaria incidence is high in Panama, only four cases of malaria occurred among the 40 laborers occupying these cars, a weekly incidence of about 0.3 per cent. The difference was due to having a man devote half an hour a day to the destruction of the anophelines found in these cars at a cost of 5 cents a day for the labor."

The above illustrations demonstrate that mosquito catching is capable of keeping the malaria incidence down to a very low figure even in hotbeds of the disease, and indicates how valuable a method this would be in the military service, where it could so easily be adopted.

The mosquitoes are caught with the chloroform tube already described in Chapter II, although Orenstein recommends that instead of cotton at the bottom of the tube to receive the chloroform a layer of short lengths of rubber bands covered with a plug of cotton be placed at the bottom of the tube and saturated with chloroform. In addition to the killing tube the mosquito hunter is also furnished with an ordinary "fly swatter" and instructed to catch or "swat" every mosquito observed. The method of catching mosquitoes with the tube has already been described (Chapter II, p. —), and the mosquitoes should be searched for in dark corners of rooms, in closets, along baseboards, beneath sinks and toilet fixtures, behind pictures, and in tents, along the ridgepole, in the corners behind clothing, and beneath cots and mosquito nets. The "fly swatter" is especially useful in killing the mosquitoes frequently observed on the outside and inside of screenings on verandas, doors, and windows. At Camp Stotsenberg, during the rainy reason, the outside of the window screens of the hospital and other buildings was frequently the resting place of scores and even hundreds of anophelines which were endeavoring to get within the buildings, and it was possible to kill hundreds of these insects in this situation almost every evening during the rainy season.

Mosquito traps have also been used extensively in the Canal Zone, and Orenstein describes one devised by Sanitary Inspector Bath, which has proved satisfactory. It consists of a half-cylinder constructed of wire netting, having two ridges inside it, "the apices of which are perforated by longitudinal slits about ¼ inch wide and 3 inches long. Through the slits in these ridges the mosquitoes enter the chamber of the trap, and can not, for some reason, find their way out again."

The traps are so placed as to catch the mosquitoes either when entering or leaving a building, and in the Canal Zone it was found that more anophelines were caught if the traps were placed on the lee of buildings, while more culicines were captured if the traps were installed on the windward side of the buildings.

Regarding the value of catching mosquitoes Orenstein well says that:

> When it is remembered that in malaria a period of at least a week must elapse before the mosquito which has fed on an infected person can transmit the infection to another person, and when it is recalled that an anopheline filled with blood becomes sluggish and does not fly very far for some time, the efficacy of killing mosquitoes within habitations becomes self-evident.

And he concludes that "catching mosquitoes by hand within dwellings is a measure of great value in the prophylaxis of malaria. It is especially applicable to temporary camps."

It is obvious that this prophylactic method might be of the very greatest value to the military service in the case of camps in malarial localities and it could be so easily put in operation that its neglect would be inexcusable. All that would be necessary would be to detail a certain number of men for the purpose, under an intelligent noncommissioned officer, the camp being districted for the purpose. No great amount of training is necessary, as mosquitoes are easily recognized and the method of handling the killing tube and "swatter" is quickly acquired even by the most unintelligent laborer, as shown by the fact that all the work in this line in the Canal Zone was done by the West Indian negro. In the field where troops are in tents for some time, as at maneuvers or in more or less permanent camps, and where mosquitoes are prevalent, this method is certainly deserving of the most thorough trial.

In barracks and quarters in posts situated in the Tropics mosquito catching would also be a valuable method of prophylaxis and could be accomplished by native help at a comparatively small expense. In many posts in the Philippines, where it has been found impossible to entirely eradicate mosquitoes, this method would be easy of application and would undoubtedly give good results in reducing the number of mosquitoes and the incidence of malaria. In temperate regions it is generally possible to rid our posts of mosquitoes by one or more of the other methods described in this chapter, but in the Tropics it is very often impossible to do more than reduce the number of these insects, and this would appear to be a great aid in that direction, and possesses the additional value that it enables us to capture and kill the mosquitoes that have bitten man and may, therefore, have become infected with malaria.

CHAPTER IV.

PROPHYLACTIC METHODS BASED UPON THE PROTECTION OF MAN FROM THE BITES OF MOSQUITOES.

Where it is impossible to destroy all of the breeding places of mosquitoes or to kill the adult insects, the protection of man from the bites of these insects becomes a most important prophylactic measure. Especially has this been found true in the military service, where this method, together with quinine prophylaxis, often has to be depended upon entirely when troops are in the field in malarial localities, and even in semipermanent camps and permanent posts the protection of the troops from the bites of mosquitoes not infrequently becomes of paramount importance owing to local conditions or for economical reasons. While, as has been stated, the abolition of the breeding places of mosquitoes is the ideal method of malaria prophylaxis either in military or civil communities and other methods should never be substituted for this where it is possible to employ it, the fact remains that in most localities it is necessary to combine all of our methods of prophylaxis, and of them the protection of man from mosquito bites is one of the most valuable.

This mechanical prophylaxis, as it is sometimes called, is secured by the proper screening of quarters and barracks, the use of mosquito nets for the beds and shelter tents, the wearing of head nets and gloves, and the use of various odorous substances which are smeared upon the skin for the purpose of preventing mosquitoes from biting.

Screening.—The screening of barracks and quarters in posts in malarial regions is a most important and valuable prophylactic measure and should never be neglected when the more permanent methods of drainage and filling in can not be employed or where their employment only reduces the number of anophelines. While, in civil life, the question of expense makes the employment of this method prohibitive in many localities, in the military service it should not enter into the question where posts are situated in regions where pernicious forms of malaria are prevalent, or where any form of malaria is prevalent to an extent that will seriously affect the efficiency of troops.

The expense involved is admittedly great, in many instances, but if good screening material be obtained, the screens will, if properly cared for, last for years, and before they are worn out will have repaid many times the initial expense by the reduction in the amount of malaria among the troops and the consequent increase in efficiency.

The selection of screening material.—The screening used for quarters and barracks should be of as durable material as it is possible to secure and of fine enough mesh to keep out all anophelines. The *material* for screening should be of wire composed of copper, zinc, and iron, the copper content being higher than that of brass. In the Tropics this is of special importance, as the heat and moisture rapidly corrode wire netting having a low percentage of copper. The observations of Nauss, in the Canal Zone, reported by Darling,[31] proved that the deterioration of wire screening in the Tropics is due to the presence of iron plus the influence of a hot and moist climate. Brass screens, by reason of the amount of iron alloy present are, therefore, unsuitable, and copper-wire screens should always be selected.

If copper screening can not be obtained ordinary iron-wire screens may be used, but they should be covered with two coats of good paint and frequently repainted. Even so, they will be found more expensive in the end than the best copper-wire screening, which should be used if it can be obtained.

The *size of the mesh* in the wire screening used to protect houses and barracks is a matter of prime importance. It must be close enough to keep out all anopheles mosquitoes, and in regions where yellow fever is endemic or may be introduced the mesh should be small enough to keep out the yellow-fever mosquito, *Stegomyia fasciata*. Nothing is gained by using a screen in which the meshes are closer than necessary, and something is lost, for the closer the mesh the more air is excluded from the room or building, and this is a matter of much importance, especially in the Tropics and subtropics.

A considerable amount of experimental work has been done along this line. As a result of my own observations at Camp Stotsenburg, in the Philippines, where anophelines were very numerous, I concluded that wire netting containing 16 meshes to the linear inch (No. 16, as it is called) excluded all the *Anopheles* tested and that this size netting should be used in the prophylaxis of malaria.[32] My observations were confirmed, so far as *Anopheles* are concerned, by Guiteras,[33] Darling,[34] and the United States Army Board[35] for the Study of Tropical Diseases in the Philippines. This netting was not efficient, however, in excluding the yellow-fever mosquito, as the majority of investigators have shown, and a netting containing 18 meshes to the linear inch should be selected when *Stegomyia* are present, as shown by the experiments of Darling and the Board for the Study of Tropical Diseases.

It is very probable that mosquitoes vary in size, even when full grown, for Goeldi has shown that delayed development during the larval stage, due to various local conditions and a poor supply of food, results in dwarfed adult mosquitoes, and this doubtless accounts for some of the discrepancies between the results of different investigators as to the efficiency of various sized wire screens.

In 1908 Col. J. R. Kean, Medical Corps, United States Army, sent Dr. Guiteras, in Habana, some 16-mesh wire screening and requested that experiments be made regarding its efficiency in excluding stegomyia mosquitoes. After many very careful experiments Dr. Guiteras reported to Col. Kean that the netting sent kept out *Stegomyia fasciata*, using the following words:

> It is my opinion that we may conclude from these experiments that the *Stegomyia calopus* (*fasciata*) can not pass through the wire gauze sent for trial. The gauze is 16-wire mesh—that is, it presents 16 wires or threads to the linear inch.

In 1910 Darling, as the result of his experiments in the Canal Zone, states:

> In regions where it is only necessary or desirable to protect against anophelines a No. 16 mesh screening (16 holes to the inch) would answer the purpose, and where, as in this region, it is necessary to protect against some of the smaller varieties, such as *Stegomyia calopus*, a No. 16 mesh would be *practically* safe, but not absolutely so.

He found that none of the anophelines in the Canal Zone could pass the 16-mesh screening, but that some specimens of *Stegomyia fasciata* (*calopus*) could, as well as several species of *Culex*.

Owing to the uncertainty caused by the divergent reports of Guiteras and Darling, the Surgeon General of the Army, in 1912, requested the Army Board for the Study of Tropical Diseases in the Philippine Islands to determine what sized copper-wire gauze would prevent the passage of anophelines and other mosquitoes. The board, as the result of very careful experiments, found that 16-mesh wire gauze was impervious to the following mosquitoes: *Myzomyia rossii*, *Mizorhynchus barbirostris*, *Pyretophorus freerae*, *Mansonia annulifera*, *Mansonia uniformis*, *Culex fatigans*, and *Culex microannulatus*. As *Myzomyia rossii* is as small as any of the anophelines connected with malaria; their observations confirm mine, made in 1905 at Camp Stotsenburg, but they also determined that this same species could be excluded by either No. 12, 14, or 16 mesh screening. In addition they found that *Stegomyia fasciata* (calopus) could pass No. 16 mesh netting with considerable ease, and concluded that while the No. 16 mesh will keep out all malaria mosquitoes found in the Philippines its use is inadvisable because it does not keep out the yellow-fever mosquito.

From these various observations it appears to me that in the military service all screening should contain at least 18 meshes to the linear inch, and I believe that it is a mistake to use wire gauze containing more than this number, both because it is unnecessary so far as practical protection goes and because it reduces by just so much the amount of air admitted to a room or building.

Method of screening.—It is a perfectly obvious fact to anyone who inspects screened buildings, either in civil or military life, that much of the screening is so constructed as to defeat, in a measure, the purpose aimed at, i. e., the exclusion of mosquitoes. The use of adjustable or folding screens; the fastening of the screen within the window, necessitating its being raised every time the window is opened; and the use of the single-screened door for quarters and barracks, instead of having double-screened doors with a screened vestibule, are all instances commonly observed of imperfect screening. In barracks that were carefully screened I have observed unscreened ventilators along the ridgepole, which explained fully the presence of numerous mosquitoes within them, an occurrence which had furnished a strong argument against screening in the prophylaxis of malaria to certain individuals who were adverse to this method. Not infrequently, while the first and second stories of quarters are carefully screened, the attic windows will be found unscreened, and mosquitoes thus gain entrance to the quarters. All of these mistakes can be easily avoided and are most important in their effect upon the success of screening against mosquitoes.

The arrangement of screens must vary, of course, with the architecture of the building to be screened, but all window screens should be placed outside window sashes and fitted as closely as possible to the sash, as otherwise mosquitoes may easily get in between the screen and sash, especially when the window is partly open. In fact, to insure perfect protection the entire window should be covered externally by one screen. In this way either the lower or upper sash may be raised or lowered without danger of admitting mosquitoes. Where wire screening is impossible doors and windows may be protected by cheese-cloth screens, which, while not very durable, are satisfactory if carefully watched for the appearance of holes and promptly replaced. All entrances to quarters and barracks where screening is necessary should be protected by a screened vestibule containing two doors instead of a single screened door opening directly into the building, which is the usual arrangement. While this method of screening may be practically sufficient where mosquitoes are not very numerous and malaria is rare, it is necessary to have the double-door entrance in regions where malaria prevails to any extent, especially in barracks, where the doors are opened so frequently. All screened doors should open outward.

Extreme care should be taken that all ventilators be screened, and that screens be frequently inspected and repaired promptly when necessary.

Mosquito nets or bars.—When it is impossible to thoroughly screen barracks and quarters, and for troops in the field, the mosquito net or mosquito bar, as it is often called, furnishes a most valuable means of protection from the bites of these insects. In the military service the ideal mosquito net would be one that could be used over the bed while the troops are in permanent barracks, and within the shelter tent when in the field. Such a mosquito net has been devised by Capt. Vedder, of the United States Army Medical Corps, and has been adopted by the Quartermaster's Department for issue to the troops. It can be easily folded and carried in the pack when troops are in the field and, if properly made, will undoubtedly be found to be a most valuable aid in preventing mosquito-borne diseases in an army during active operations, besides greatly increasing the comfort of the troops when campaigning in regions where mosquitoes abound.

In barracks where mosquito nets are used there should be a nightly inspection of the nets after taps, to insure their being used by every man and that they are being properly used. Care should be taken to see that each net is tucked under the mattress, instead of hanging loosely around the bed, as otherwise mosquitoes easily gain entrance by crawling or flying between the net and the mattress. During the day the mosquito net should be preferably taken down and folded up on the bed, but may be either tucked in beneath the mattress if the bed is made up or folded over on the portion suspended between the uprights. The greatest care should be taken to keep the net in repair, all holes being darned as soon as they are discovered.

Head nets and gloves.—Head nets and gloves are absolutely necessary in many regions if one is camping or hunting, and the same is true when troops are in the field in such localities. The Quartermaster's Department of the Army issues a very good head net, so fashioned as to fit over the campaign hat, and this will be found of the greatest service, especially to the men on guard, and their use should be insisted upon in malarial localities. I am convinced that if a head net had been worn by men on guard at several of the posts in the Philippines it would have greatly reduced the amount of malaria, for many cases of infection occurred that could be traced to the soldiers being severely bitten during guard duty.

The use of odorous substances on the skin.—Various substances have been recommended for protecting the skin from the bites of mosquitoes. Among the best may be mentioned the oils of citronella, eucalyptus, pennyroyal, anise, camphor, vaseline, and kerosene. As a rule the slight protection afforded by these substances has not led to any extensive use of them in the military service, but there may be circumstances in which the use of one or the other of them may prove of value. Such an instance is quoted by Howard,[36] who states that Dr. W. H. Dade, United States Army, found a mixture of one part of bergamot oil to sixteen parts of kerosene very efficacious in preventing mosquito bites when smeared on the skin, and that this mixture was successfully used by troops when on marches in the Philippines.

For use, as a temporary measure, a mixture of oil of citronella and vaseline, when smeared upon the skin, is very serviceable and is not unpleasant. If liquid vaseline is used, about one part of oil of citronella should be mixed with six parts of liquid vaseline and applied frequently when exposed to the bites of mosquitoes. If liquid vaseline can not be obtained ordinary vaseline may be used, a teaspoonful of the oil of citronella being mixed with two ounces of vaseline.

It is obvious that the use of substances that are only temporary in their protective power and that depend entirely upon the will of the individual for what success they may have, are not of any great value in the prophylaxis of malaria in the military service. Such methods are miserable makeshifts and should be rendered unnecessary by the adoption of more scientific and valuable ones.

The value of screening and the use of the mosquito net has been abundantly proven by practical experiments, beginning with that of Sambon and Low. These investigators, in order to test the truth of the theory that the malarial infections are transmitted by mosquitoes, spent an entire summer at Ostia, a most malarious region in the Roman Campagna, residing in a mosquito-proof hut. During the day the time was spent mostly out of doors, but early in the afternoon the observers retired to their hut and there spent the night. Neither investigator developed malaria, although it was said, by the natives, that to spend one night in that place would result in a malarial paroxysm, and most of the inhabitants who were not protected by screens developed the disease during the summer the observers spent there.

Of the notable instances of the protection from malaria afforded by screening may be mentioned the experiments of Procaccini, in Sardinia, and of Tzuzuki, in Formosa, with military troops; and in the Canal Zone, in the settlements of Gatun and New Gatun, as reported by Orenstein.

Procaccini,[37] in Sardinia, reduced the number of cases of malaria among the soldiers from 70 per cent to 57 per cent, in one season, by screening the barracks, and later the percentage was reduced to less than 20 per cent.

In Formosa, Tzuzuki [38] tested the efficiency of screening by selecting 115 soldiers of a battalion stationed at Kirun, a most malarious locality, and furnishing them with screened barracks, the remainder of the battalion being unprotected from the bites of the mosquitoes. The 115 soldiers were thus protected from September 21 to December 8, the malarial season, and not a case of the disease developed among them, while, in the same time, among the 750 soldiers not so protected there developed 319 cases of malaria. The men were confined in the screened barrack from half an hour before sunset to half an hour after sunrise during this time, and wore head-nets and gloves when on service at night.

Orenstein[39] gives a most interesting account of the value of screening as illustrated in the settlements of Gatun and New Gatun, in the Canal Zone. Gatun had a population of approximately 4,500, residing in screened quarters, while New Gatun, having a population of about 5,000, had no screened quarters. With this exception the surroundings were identical so far as chances for malarial infection were concerned. Observation extending over three years showed that the malarial incidence for Gatun and New Gatun was as 2 is to 3, the following being the yearly incidence in each settlement:

Year.	Gatun.	New Gatun.
	Per cent.	*Per cent.*
1909	5.35	10.04
1910	5.37	9.21
1911	8.75	12.59

In his conclusions Orenstein says:

> A properly screened dwelling can be depended upon to reduce by at least one-third the malaria incidence in a locality where malaria is endemic.

These instances illustrate how valuable a prophylactic method we possess in screening when it is efficiently applied, but it should be remembered that it is far less valuable than is the abolition of the breeding places of mosquitoes when this can be accomplished. However, as has been repeatedly stated, it is only under exceptional conditions that one is able to entirely rid a locality of mosquitoes, and it therefore follows that screening must always remain one of our most valuable accessory methods in the prophylaxis of these infections. In the field, of course, we must depend entirely upon the use of the mosquito net and quinine in the prophylaxis of malaria among troops, but in permanent posts screening should not be depended upon to the exclusion of other prophylactic measures, but should be used along with them.

Screening of malarial patients.—In concluding this chapter I desire to call attention to the very great importance of screening all malarial patients as long as the plasmodia can be demonstrated in any number in the peripheral blood. It is obvious that if we place the infected individual in a position where mosquitoes can bite him the mosquitoes will become infected, provided *gametes* are present, or the patient may become reinfected by the bite of an infected mosquito. Despite these facts I have several times observed malarial patients in a common ward lying unprotected by a mosquito net, although the ward was not screened and anophelines were present. It is needless to comment upon such a situation, but it is one that will continue to occur, in isolated instances, until the malarial fevers are considered as infectious diseases and the same precautions taken to prevent their spread as would be taken in the case of yellow fever.

In a carefully screened ward it would be unnecessary, of course, to further screen a malarial patient, but in an unscreened ward this should always be done, and, under such circumstances, it is better to place the patient in a room by himself, the same precautions being taken regarding screening, nor should he be allowed to leave the screened quarters until the plasmodia have either disappeared from his blood or been reduced to a noninfectious minimum. This will, of course, necessitate a microscopic examination of the patient's blood at daily intervals, but it is only by such an examination that we can adequately control the treatment of malaria and render the prophylaxis of the disease effective, so far as the patient is concerned. The screening of every individual in hospital for malarial fever is an absolutely necessary prophylactic measure if one desires to limit the spread of these infections.

CHAPTER V.

PROPHYLACTIC METHODS BASED UPON THE DESTRUCTION OF MALARIA PLASMODIA (QUININE PROPHYLAXIS).

It is obvious that if we can destroy or prevent the development of the malaria plasmodia in infected individuals we will succeed in preventing the disease, as it will thus be impossible for mosquitoes to become infected. This fact is the basis of quinine prophylaxis, which consists in the administration of this drug to all individuals harboring the plasmodia and to all those exposed to the bites of mosquitoes capable of transmitting the plasmodia to man.

Perhaps no method in the prophylaxis of the malarial fevers has given rise to more controversy than the use of quinine as a prophylactic. Enthusiasts in its favor have claimed that the use of this drug alone is all that is needed to eradicate malarial infections from any locality, while its most violent enemies have claimed that it is not only practically useless but even harmful. It is evident that the truth must lie somewhere between these extreme opinions, and it is my belief that quinine prophylaxis is a most valuable method, but one that should not be relied upon to the exclusion of other methods except under conditions that render the combination with other methods impossible.

From the observations of many investigators we know that quinine is capable of destroying the plasmodia while they are in the blood of man, and from clinical observation we know that this destruction is followed by the disappearance of the symptoms of infection and the recovery of the patient. In other words, quinine is a specific in the treatment of malaria, and to deny the efficacy of the same drug, when properly administered, in the prophylaxis of the same disease is absurd. If quinine can destroy the plasmodia after symptoms of infection are present, it will certainly destroy them before they become numerous enough to cause symptoms; but experience has shown that enough of the drug must be given to really destroy the parasites, and that this means that considerable doses have to be taken and have to be continued just as long as the individual is exposed to malaria mosquitoes.

The most ardent advocates of this method of prophylaxis, as Koch, have claimed that by it alone it is possible to rid a community of malaria, but in practice this result could only be attained where the drug could be administered to every individual in the infected locality for a long period of time, for the prophylactic use of the drug would have to be continued as long as *Anopheles* were present, for just so long would there be danger of the spread of the disease from the mosquitoes becoming infected by imported cases of malaria. Therefore it follows that while quinine prophylaxis is a method of the very greatest value in the prevention of malaria, it can not be depended upon alone, but should be combined with those that have already been described.

The results achieved by this method of prophylaxis have varied greatly in different localities, depending upon the methods of administration and the form of quinine used; the efficiency with which the administration of the drug has been conducted; and the class of people with whom the method has been tried; so that the literature is filled with discordant reports regarding the value of the drug as a prophylactic. Most of the unfavorable reports have been the result of careless application of the method or of lack of control of the people to be benefited. It is obvious that to be successful the drug must be regularly administered, and in the military service this can be done, whereas it might be impossible in civil communities. It is true, however, that even when the method has been given the most careful trial it has failed, in rare instances, to have much effect upon the incidence of malaria; but the experience of numberless observers of the great value of the method when properly applied leaves no doubt of its worth, and the rare failures recorded must have been due to exceptional conditions surrounding the experiments.

Among the arguments that have been urged against quinine prophylaxis may be mentioned the production of haemoglobinuria, harmful physical effect upon the consumer, the difficulty of application, and the danger of producing a resistant strain of the plasmodia by the exhibition of small doses of quinine over long periods of time. As a matter of fact none of these objections are valid, and there is practically no proof that any of them possess actual merit sufficient to forbid the use of quinine in this manner. Haemoglobinuria is sometimes produced by quinine, but very rarely where the drug is taken regularly, and the few instances in which it does occur is no argument against the use of the drug. There is absolutely no scientific proof that the taking of quinine, even in much larger doses than are used in prophylaxis and continued for weeks and months, produces any harmful effect, and even the slight dizziness and roaring in the ears disappear after taking the drug in prophylactic doses for a few days. The danger of producing quinine-fast strains of the plasmodia in this manner is simply a theory without any proof of scientific value, while the objection regarding the difficulty of applying the method is true of many other prophylactic methods and a poor excuse for its neglect. Certainly in the military service, where men are under absolute control, there can be no excuse for neglecting quinine prophylaxis when it is needed, because it requires careful supervision and therefore entails labor upon the sanitary personel. Quinine prophylaxis has been found of the greatest service in keeping down the incidence of malaria in some of our permanent posts in the Philippines, and during active operations by troops in the field in malarial regions it will always have to be our chief defense against these infections. It is therefore essential that the medical officer be acquainted with the various methods of applying this form of prophylaxis, which includes a knowledge of the effect of quinine upon the plasmodia; the form and time of administration of the drug; the proper treatment of initial infections, of latent infections, and of *gamete* carriers; and, finally, of the results that may be expected from this method when it is efficiently applied.

Action of quinine upon the malarial plasmodia.—In 1867 Binz demonstrated that quinine in solution killed infusoria with which the solutions were brought in contact, and concluded from this that its effect in malaria was due to the destruction of the cause of the disease. In 1881 Laveran demonstrated that quinine solutions, when added to blood containing the plasmodia, produced immediate cessation of the movements of the plasmodia, while Golgi, Romanowsky, Mannaberg, Zieman, Schaudinn, and others described degenerative changes produced by the drug in the various species of plasmodia. The results of these various observers were often conflicting, and many of their conclusions were founded upon insufficient evidence. In 1910 I [40] published the results of continued studies upon the effect of quinine on the various species of plasmodia, as shown in both fresh and stained preparations of blood, and these results have since been confirmed by many observers. They may be summarized as follows:

Plasmodium vivax (*tertian plasmodium*).—In *fresh* preparations of blood obtained after the administration of quinine marked morphological changes are observed in every stage of development, with the exception of the stage just preceding sporulation and in the fully-developed *gametes.* The morphological changes observed in the *living* organism consist in an initial stimulation of amoeboid activity, followed by a decrease in activity, and eventually by cessation of all motion; a granular degeneration of the cytoplasm which has an increased refractive index; fragmentation of the plasmodium, followed by the apparent extrusion of the fragmented organism from the red corpuscle; and an apparent increase in the amount of pigment in those organisms which undergo development in spite of the quinine. In *stained* preparations the morphological changes are much more apparent, consisting in poor staining reactions of the cytoplasm, while the chromatin of the nucleus stains darker and is stainable long after the cytoplasm has ceased to stain: the prevention of normal increase in the amount of chromatin, as shown by the plasmodia containing much less of this material at certain stages of growth than normal; the prevention of normal division, as shown by plasmodia in which only a portion has divided, thus producing atypical sporulating forms; and sporulating forms in which many of the spores or *merozoites* are devoid of chromatin. Many of the organisms show undoubted evidences of fragmentation in the stained preparations. The changes observed are present at every stage in the development of the organism except when quinine has been given just before sporulation and in the fully-developed *gametes*.

Plasmodium malariae (*quartan plasmodium*).—The changes produced by quinine, as shown in fresh and stained preparations of blood containing *Plasmodium malariae*, are essentially the same as those produced in *Plasmodium vivax*, and while there is some evidence that this species is slightly more resistant that the tertian plasmodium my observations showed that even the older parasites were affected, just as in the case of the tertian species.

The estivo-autumnal plasmodia.—In both species of estivo-autumnal plasmodia quinine produces practically the same changes as in the tertian and quartan species, except that fragmentation is not so frequently observed. The crescentic *gametes* of the estivo-autumnal plasmodia appeared unaffected by quinine so far as any morphological changes are concerned.

My observations proved that the old theory that only the young spores are affected by quinine and that the drug must be in the blood at the time of sporulation is untenable, for while the *merozoites* are undoubtedly more easily affected by the drug than the older forms, the changes in morphology of the *schizonts* almost up to the time of sporulation demonstrate conclusively that quinine causes degeneration in even the older plasmodia. Recent observers have confirmed my observations regarding the action of quinine upon the later stages in the development of the plasmodia and upon the morphological changes that are produced in these organisms by the drug. Rieux[41] studied the action of the drug upon the tertian plasmodium and found that not only were the young *schizonts* affected, but that if the drug was commenced 24 hours after the paroxysm when the *schizonts* were half grown many of them were arrested in development and fragmentation occurred in a considerable percentage. He found that the sporulating bodies were not affected, but that the continued use of quinine caused degeneration of the *gametes* and eventually a disappearance of these forms from the peripheral blood. Billet's[42] observations confirmed those of Rieux; and James[43], in the Canal Zone, obtained the same results from his studies of the action of quinine upon the plasmodia.

From these observations it is evident that quinine is capable of affecting the plasmodia in practically every stage of their development, and it follows that the best results will be obtained in prophylaxis and treatment if the drug is present in the blood continually. Thus, I am a firm believer in divided doses at regular intervals in the treatment of all forms of malarial infections, except, of course, the pernicious cases, where a large dose of the drug must be administered at once; and in the prophylaxis of the disease I believe that better results will be obtained if quinine be given in morning and evening doses rather than in one dose during the 24 hours. The object desired is to have a maximum quantity of the drug continually present in the blood, and the nearer we approach this ideal the better will be our results with the quinine prophylaxis of malaria. In the field, of course, it would probably be necessary to depend upon one dose, given either in the morning or evening, but in camps and posts a morning and evening administration of quinine could be arranged and enforced in the vast majority of instances.

The form of quinine to be used in prophylaxis.—Until quite recently we have been very ignorant regarding the exact fate of quinine after ingestion and the salts or compounds of the drug best fitted for use in the prophylaxis and treatment of malaria. The researches of Gaglio, MacGilchrist, Webb, and others have demonstrated that many of our ideas regarding the pharmacology of this drug were erroneous and have resulted in new points of view as to its use in malarial infections. Thus, the old idea that the salts most soluble in water should be preferred, because they would be more readily absorbed has been proven incorrect, for Gaglio has shown that the insoluble salts and compounds are as well absorbed as the most soluble salts of the alkaloids, and that the drug is absorbed mostly in the intestine combined with the biliary acids and carbonic-acid gas. It has also been shown that if the drug is taken daily it accumulates in the blood up to about double the initial dose, and that it is eliminated through the kidneys, elimination never taking longer than three days, no matter how administered or what preparation is administered. The least soluble preparations have been found the best tolerated by the stomach and intestines, because of their more gradual absorption, and MacGilchrist has shown that the *acid* salts are strong hemolytic agents outside the body and are, therefore, less safe than the neutral salts or quinine alkaloid itself.

In the selection of the form of quinine to be used in prophylaxis all of the points enumerated are of importance, owing to the length of time that the drug must be administered. If there is serious danger of the production of hemoglobinuria by the constant administration of the acid salts of quinine they should not be used; but, as a matter of fact, there is no evidence that the prophylactic use of any of the acid salts has resulted in the production of any appreciable amount of hemoglobinuria, so that it may be stated that they may be used in prophylaxis without danger. It should also be remembered that the proper treatment of initial malarial infections and of "carriers" of the disease are most important prophylactic methods, so that the consideration of the form of quinine to be used in prophylaxis must not only take into consideration what form can be used most successfully in preventing the disease, but also what form is most efficient in curing those already infected.

Of the many salts and compounds of quinine that have been used in the prophylaxis and treatment of malaria I believe that, from a military standpoint, the only ones deserving of consideration are the sulphate, the dihydrochloride, tannate of quinine, and the quinine alkaloid. Of these the sulphate and the dihydrochloride (hydrochlorsulphas) are on the supply table, and, in my opinion, are all that are needed in the prophylaxis and treatment of malaria in the Army, although for prophylactic use the tannate might be adopted with benefit.

This is the salt that has been so successfully used in Italy in the prophylaxis of the disease and which Celli regards as the ideal one for this purpose, owing to the fact that it is almost tasteless, is well tolerated by the stomach, is absorbed more slowly, and is more completely oxidized than other salts of the drug. For the treatment of those already infected it is inferior to the sulphate or dihydrochloride. MacGilchrist[44] has recently urged the adoption, both for prophylaxis and treatment, of the amorphous precipitated quinine base or alkaloid for the following reasons: 1. It is sparingly soluble in water and almost tasteless. 2. Absorption is as quick and complete as after the administration of quinine salts. 3. Being pure quinine it represents quinine in the smallest bulk and weight. 4. Being nonhemolytic it is safer. 5. Low cost. If further experience shows that these contentions are correct it would appear as though quinine alkaloid possesses advantages over salts of the drug, but experience has shown that the sulphate of quinine can be relied upon in prophylaxis and treatment in the military service, and there would seem to be no great advantage to be gained by carrying on the supply table several preparations of the drug. So far as the danger of the sulphate producing hemoglobinuria is concerned, the statistics of the Army demonstrate that it is infinitesimal, for despite the immense amount of this salt that has been used in the prophylaxis and treatment of malaria among our soldiers since 1898, hemoglobinuria has been so rare as to be a medical curiosity.

Methods of administration and dosage.—In discussing this question two problems must be considered, i. e., the best method of administration of quinine to prevent infection and the dose required and the best method of curing initial infections and carriers of the disease. The latter will be discussed under a separate heading, and I will here give the various methods of quinine prophylaxis that are intended to directly protect the individual from infection by the plasmodia.

All methods of quinine prophylaxis may be divided into two classes—i. e., those in which the drug is administered daily and those in which the drug is administered at larger intervals. The latter methods are all aimed at doing away with the irksome daily administration, but all have the fault that one must remember the days upon which quinine should be given, with the result that many doses are missed, while there is good evidence showing that none of them are as effective in prophylaxis as the daily administration of the drug.

The following are the chief methods of using quinine as a prophylactic, together with the doses advocated:

Celli's method.—The daily administration to adults of 40 centigrams (6 grains) of quinine, 20 centigrams in the morning and 20 centigrams in the evening. To children, 20 centigrams (3 grains), 10 centigrams in the morning and 10 centigrams in the evening.

Sergent's method.—The administration in one dose, daily, of 20 centigrams (3 grains) of quinine.

Zieman and Nocht's method.—The administration of 1 gram (15 grains) of quinine every fourth day, given in 0.25-gram (4-grain) doses.

Plehn's method.—The administration of 1 gram of quinine (15 grains) every seventh day.

Koch's method.—The administration of 1 gram (gr. xv) every sixth and seventh, seventh and eighth, eighth and ninth, or ninth and tenth days, according to the severity of the infections present.

While our choice of the exact method of giving quinine as a prophylactic will be influenced in the military service by local conditions, I believe that the method of Celli, supported as it is by years of success in practice, will be found the most efficient one for adoption by troops campaigning in a malarial country. The giving of the drug in morning and evening doses would probably often have to be replaced by the practice of giving the entire amount in one evening dose, but the *daily* administration of the drug I believe to be essential to the success of malarial prophylaxis in an army in the field. For such service, then, I would recommend the administration of 40 centigrams (6 grains) of quinine sulphate to *every soldier every day*, preferably in an equal morning and evening dose, but if this is impracticable, in a single dose at evening.

In regard to malaria prophylaxis in semipermanent camps and permanent posts, the daily administration of the drug in the dose indicated, with the proper reductions in dose in women and children, will likewise be found the most efficient method; but if for any reason this method can not be adopted, the administration of 1 gram (15 grains) on the evening of every third day should be preferred to any other of the *interrupted* methods of quinine prophylaxis. The reason for this is evident. It has been shown that all of the quinine taken at any one time is entirely eliminated within 72 hours, so that if an interrupted method of giving the drug is adopted it should be one in which there is no time when the blood is entirely free, and this can only be accomplished by selecting one in which the dose is repeated within 72 hours. While with the method advocated there will be a period of an hour or so in which the blood is free from quinine, this can be disregarded in practice. This method has the advantage also that it is easier to remember to take the dose of quinine every other day than at the fourth, ninth, and other days required by some of the methods of quinine prophylaxis already mentioned. The more simple we make our methods of prophylaxis the better they will succeed, especially with soldiers, and for this reason I do not favor the complicated methods advocated by some authorities in which quinine is to be taken at irregular intervals. The two methods outlined here will be found efficient in practice, the choice, if possible, resting with the daily administration of the drug.

The administration of smaller doses of quinine than those advocated in the prophylaxis of malaria should be discontinued both because smaller doses are inefficient and because if there is any danger of the production of quinine-fast strains of the plasmodia they are much more apt to be produced by doses of 1 and 2 grains of quinine daily than by the amount recommended. Personally, I see no proof that such strains have ever been developed, and while the theory is fascinating, especially in the explanation of resistant infections and relapses, there is no scientific evidence that such forms of the plasmodia actually exist. Therefore, my objection to smaller doses of quinine than those mentioned is based almost entirely upon my conviction that such doses are insufficient to prevent infection and are practically useless in the prophylaxis of malaria.

It should be distinctly understood that the dosage of quinine recommended to prevent malarial infections in the healthy has nothing whatever in common with that employed in preventing relapses in the infected or in the treatment of "carriers" of the infection. These subjects will be shortly referred to, but the experience of Celli, in Italy, absolutely demonstrates that quinine given in the manner here recommended does prevent malarial infections, although some authors, as Thomson, would have us believe that much larger doses are necessary. It is true that larger doses have to be used in the treatment of the infected, but for the prevention of the disease in the uninfected the doses recommended will be found efficient in the very great majority of instances.

As a prophylactic quinine must be administered by the mouth. When given in this way it may be administered in the form of a solution, pills, tablets, capsules, wafers, troches, and confections. In the military service the solution and tablets are about the only practicable forms where large bodies of men are to be treated, and in the field the cheapest and most useful method of dispensing the drug is in the form of tablets containing the required dose. Nowadays excellent tablets may be obtained, but even so, the utmost care must be used to see that quinine is really being supplied and that the tablets are soluble. We are all familiar with the insoluble quinine tablet and pill, but at the present time the tablets upon the market are satisfactory in this respect and will be found efficient.

The solution of quinine may be employed in camps and posts and possesses the advantage that the drug is more readily and quickly absorbed and there is little chance of the soldier evading the taking of the dose. The solution is prepared by dissolving 0.32 grams (5 grains) of quinine sulphate in 4 c. c. (1 dram) of distilled water to which one drop of concentrated hydrochloric acid has been added. A large amount of this solution can be made up at one time, as it keeps well, and can then be dispensed as needed.

In order to be effective the administration of quinine as a prophylactic must be under the direct personal supervision of a medical officer, and this duty should not be delegated to any subordinate, but should be considered one of the most important *personal* duties that the sanitary officer is called upon to perform. Many of the reported failures of quinine prophylaxis in troops have been due to the relegation of this duty to careless subordinates and their inefficient application of the particular method selected, with the result that the method has been condemned without a fair trial.

The proper treatment of malarial infections and of "carriers" in the prophylaxis of the disease.—It is well known that after an attack of malarial fever has persisted for from 8 to 10 days or more, provided insufficient quinine has been given, there develop in the blood of the infected individual forms of the plasmodia known as *gametes*, which are capable of infecting anopheline mosquitoes, and eventually of rendering these insects capable of transmitting malaria to man. It is evident that if these forms could be prevented from developing mosquitoes could not become infected and malaria could not be transmitted. It follows, therefore, that if quinine will prevent the formation of *gametes*, and it will, every patient presenting these forms in the blood is an evidence of the improper treatment of his infection by his physician, provided, of course, that they were not present when he was first seen, as the result of a latent or very mild infection. As a matter of fact the vast importance of the proper treatment of the infected in the prophylaxis of the malarial fevers has never been fully realized by the profession or even by officers engaged in sanitation in malarial regions, for there is nothing more common, in many such localities, than to see *gamete* carriers going about their daily occupations without having received any advice regarding treatment and wholly ignorant that they are a danger to the people of the community in which they reside. In much of our prophylactic work in the military service this phase of the subject appears to have been entirely overlooked and it is because of their importance in the prophylaxis of malaria that the subjects that follow are here discussed.

In any thorough campaign against the malaria fevers the discovery and treatment of latent infections, the treatment of *gamete* carriers, or carriers of malaria, and the proper treatment of initial and recurrent cases of the disease are fully as important as other methods of prophylaxis, and yet, until recently, these subjects have been looked upon as being practically outside the province of the sanitarian and of preventive medicine. As a matter of fact, the prevention of "carriers" of any infection and the treatment of those who have become carriers is one of the most important function of preventive medicine, while the discovery of latent infections and their treatment would logically appear to be the first step in the prevention of any disease. This has been found to be true in typhoid fever, diphtheria, entamoebic dysentery, cholera, and other infectious diseases and it is equally true in the malarial infections.

The discovery and treatment of latent infections.—By a latent malarial infection we understand one in which the plasmodia may be demonstrated in the peripheral blood, but in which no clinical symptoms of sufficient gravity to attract attention are observed. The term includes both those instances in which no definite symptoms of malaria have ever been observed, and those cases in which the disease is latent between recurrences.

It is well known that in malarial localities a considerable proportion of individuals in apparently fair health are "carriers" of the plasmodia, and that the natives of these regions possess an acquired immunity to the usual effects of the malaria toxin, although the plasmodia may develop in such individuals and be demonstrable in the blood. It has also been shown that insufficient treatment of malarial infections results in the production of carriers of the disease and that many patients discharged as cured from the hospital will be found to have plasmodia in their blood for long periods before a relapse occurs, and that many of these become efficient "carriers" of the disease owing to the development of *gametes* during these latent periods.

Proportion of latent infections.—The proportion of latent infections varies greatly in different localities as is shown by the tables that follow, but it may be stated that such infections occur in a considerable percentage of both children and adults in every region in which malaria is endemic to any extent, and that the discovery and treatment of these infections is of great importance in the prophylaxis of malaria in such regions. In the following tables the percentage of malaria in the cases recorded was determined by the finding of the plasmodia in the blood, which is a much more accurate method than the splenic index which will be discussed later.

Koch,[45] to whom we owe practically the first observations along this line, concluded, from his work in Africa, that latent malarial infections were almost entirely confined to children, but further observations have shown that latent infection is very frequent in adults in malarial localities, and that the true index of the prevalence of the disease in any region can only be determined by the examination of the blood of both children and adults. The following tables give the results of the principal investigations in regard to the prevalence of latent infections in the natives of malarial regions:

TABLE I.—*Thomas's observations in Manos, North Brazil.*[41]

Age.	Number examined.	Number infected.	Percentage.
6 months to 2 years	9	3	33.3
2 years to 5 years	38	20	52.6
5 years to 8 years	51	28	54.9
8 years to 10 years	59	27	45.7
Total	157	78	49.6

James,[47] in India, found the percentage of latent infection in native children to vary greatly in different localities. At Mian Mir children up to 2 years of age showed 80 per cent infected; up to 5 years, 66 per cent; up to 10 years, 50 per cent, while children older than 10 years showed no infection. At Ennur children up to 3 years years of age showed 65 per cent infected; up to 5 years, 51 per cent; up to 10 years, 46 per cent, and up to 15 years, 16 per cent.

At Camp Stotsenburg, in the Philippine Islands, I[48] have examined the blood of 45 native adults and 180 native children, all of whom at the time of examination were free from symptons of malaria. The following table gives the results of these examinations, but only includes 147 of the children, as only in this number could I obtain the exact age.

Table II.—*Craig's observations at Camp Stotsenburg, Island of Luzon, Philippines.*

Age.	Number examined.	Number infected.	Percentage.
1 to 5 years	40	30	75
5 to 10 years	54	20	37
10 to 15 years	53	13	24.5
Adults	45	28	62.2
Total	192	91	47.3

The large percentage of adults showing latent infection in this locality was contrary to the reports of Koch, James, and others that only the children in malarial localities suffered from latent infection, but my observations have since been confirmed by numerous observers, as is shown in the following tables:

Table III.—*Ollwig's observations in Dutch East Africa.*[49]

Age.	Number examined.	Number infected.	Percentage.
Under 1 year	93	33	35.4
1 year to 5 years	220	83	37.7
5 years to 15 years	971	109	11.2
Adults	650	105	16.1
Total	1,934	330	17.0

Table IV.—*Sorel's observations on the Ivory Coast, Africa.*[50]

Age.	Number examined.	Number infected.	Percentage.
Under 1 year of age	134	75	56
1 year to 5 years	253	141	56
5 years to 15 years	328	125	38
Over 15 years (adults)	275	110	43
Total	990	451	44.4

Table V.—*A. Plehn's observations in Kamerun, West Africa.*[51]

Age.	Number examined.	Number infected.	Percentage.
Under 2 years	18	17	94
Between 2 and 5 years	26	24	92
Between 5 and 10 years	40	34	85
Adults	43	26	60
Total	127	101	79.5

TABLE VI.—*Sergent's observations in Algeria, Africa.*[52]

Age.	Number examined.	Number infected.	Percentage.
1 to 5 years	1,316	267	20.2
6 to 10 years	1,360	326	23.9
11 to 15 years	933	272	29.1
Adults	2,471	722	33.3
Total	6,080	1,587	26.1

In Pabna Hope found that while 922 adults showed latent infection only 862 children showed the plasmodia, thus demonstrating that in this locality the adult latent malaria ratio was higher than the ratio in children.

If we consolidate the data relating to latent malarial infection obtained from different localities it will be found that the percentage of infection varies but little in adults or children in badly infected localities, as is shown by the following table compiled from the observations of the authors quoted and from my own:

TABLE VII.—*Consolidated table showing the prevalence of latent malarial infections at various ages.*

Age.	Number examined.	Number infected.	Percentage.
1 to 5 years	1,684	502	29.8
5 to 10 years	1,645	463	28.1
10 to 15 years	1,390	437	31.4
Adults	4,931	1,139	23.0
Total	9,650	2,541	26.3

From these observations, which comprise only a few of the many relating to latent infections, one may gather an idea of the immense importance of this subject in the prophylaxis of the malarial fevers, where anopheline mosquitoes can not be reduced beyond a noninfectious minimum, and as this is true of the majority of places in the Tropics the recognition and treatment of the latent infections among the surrounding native population is absolutely necessary in order to control the disease. This was demonstrated at Camp Stotsenburg, where a very large part of the infection present among the troops was contracted from the latent infections present in the native population surrounding the post. Although the greatest precautions were taken regarding the abolition of the breeding places of mosquitoes and the use of mosquito nets in the barracks, the troops suffered greatly from malaria, and it was not until the examination of the blood of the natives in the surrounding barrios showed that practically 50 per cent of them were "carriers" of the infection that the prevalence of malaria among the troops was fully explained. It is undoubtedly true that a quarantine against the little barrios in close proximity to this post would have very greatly reduced the amount of malaria among the troops at that time, as the observations upon the latent infections in the natives proved conclusively that much of the malaria existing among the troops at Camp Stotsenburg was due to infection received while visiting the barrios and that any efforts to limit the disease in the post must take this condition into account. It will thus be seen that latent infection among the natives in a country occupied by troops is a most important factor in the spread of malaria, and that the discovery and, if possible, the treatment of these infections, is necessary in the prophylaxis of the disease.

Not only are the natives in a malarial region a source of danger to troops, but latent infections among the soldiers themselves furnish a constant menace to the health of the command. Improperly treated cases of the disease almost always become "carriers" of the infection, and it is just as important to recognize latent infection among the troops as it is among the native population. As an illustration of this I may mention the results of an examination of the blood of a company of United States soldiers returning from the Philippine Islands in 1902.

In August, 1902, Company H, Sixteenth Infantry, United States Army, reached San Francisco from the Philippine Islands, having served in the Cagayan Valley, a notoriously malarial region in those islands. On August 16, 1902, this company, out of a total strength of some 60 men, had 14 men in hospital suffering from malarial infection, all having had chills since arrival in the United States. On account of this large proportion of sick in hospital, I believed it would be advisable to make a blood examination of the entire company, and accordingly, on August 17 and 18, I examined the blood of every man on duty in Company H, with the following results: Of the 47 men who were doing duty and were apparently in good health, I found that 27, or over 57 per cent, showed some form of malaria plasmodium in their blood. Of these 27 men, 25 were infected with the estivo-autumnal plasmodia and 2 with the tertian plasmodium. Of these men no less than 13 showed crescents or *gametes*, and were, therefore, carriers of malarial infection, while the remainder showed the forms observed in the human life cycle of the plasmodia. It is unnecessary to discuss the importance, from a prophylactic standpoint, of such a body of men, should they have entered a territory in which anopheline mosquitoes were present but in which malarial infections were absent, nor is it necessary to speak of the importance of properly treating such infections in the prevention of the disease. One thing, however, should be emphasized, and that is that had these men been properly treated in the beginning their infections would have been cured and they would not have become carriers of the disease.

Methods of recognizing latent infections.—We have two methods of recognizing latent malarial infections—the examination of the blood and the palpation of the spleen, which is generally enlarged. Of these methods the examination of the blood is altogether the most accurate, although it involves considerable labor, and for this reason is often neglected. The splenic index, as it is called, is often a valuable guide as to the prevalence of malaria in a locality, but this organ is enlarged from other causes than malaria, and this fact often renders the splenic index misleading. In addition, the enlargement of the spleen may simply mean past infection and does not always indicate that treatment is needed at the time of examination. Where blood examinations can not be made, the splenic index must be relied upon, but in the military service, when it is desired to ascertain the actual amount of malaria present, blood examinations of the natives should always be depended upon, and in the prophylaxis of the disease among the troops a blood examination should always be made before patients are returned to duty after an attack of malaria and in any effort to discover latent infections among the men. Every medical officer should be familiar with the appearance of the various species of malaria plasmodia in both fresh and stained preparations of blood, and for this reason the detailed description of these organisms and the methods of demonstrating them have been given in the opening chapter of this contribution. It is true that much time and patience is required in making an estimate of latent infection in a native population and in discovering these infections in the men of a command, but the importance of the procedure is so great that it is time well expended, and the labor involved is no excuse for the neglect of this very valuable prophylactic measure.

The treatment of latent infections.—Immediately upon the discovery of latent infections treatment should be commenced, and the treatment will vary with the particular species of plasmodium present, and whether *gametes* have developed. The treatment of the latter class of cases will be considered in the following section dealing with "carriers" of malaria, as it differs widely from that necessary in those individuals in whom only the forms of plasmodia concerned in the human cycle of development are present, comprising approximately 50 per cent of all latent infections.

The proper treatment of the class of cases just referred to is imperative if one wishes to prevent the development of *gametes*, for in the vast majority of such cases it is only a question of time before they will become "carriers" of the disease, for while *gamete* formation may be delayed it undoubtedly occurs at some time in the vast majority of latent infections, as has been repeatedly shown by blood examinations in individual cases. Fortunately, these infections, before the formation of *gametes*, are even more amenable to treatment than acute infections, and I believe that I am safe in stating that every one of them can be cured if properly treated.

So far as prophylaxis is concerned, the object of treatment in latent infections in which only the forms of plasmodia belonging to the human life cycle occur, is to prevent the individuals harboring these forms from *becoming* carriers of malaria, as they will be if *gametes* are allowed to develop. As these individuals are not infective to mosquitoes, because *gametes* have not yet developed, there is no necessity for isolating and screening them, and as they present no symptoms the treatment may be pursued while they are attending to their ordinary avocations. In the case of soldiers it is not necessary to relieve them from duty, provided arrangements can be made for them to receive treatment at stated intervals under the direct supervision of a medical officer, so that the treatment of these infections need not interfere materially with military duties nor seriously deplete the strength of the command. It goes without saying that the discovery and treatment of latent malarial infection, so far as the military service is concerned, must be confined to semipermanent camps and permanent posts, as these measures would be impracticable in active service in the field where protection from malaria must depend upon quinine prophylaxis, the use of the mosquito net, and other measures for protecting the men from the bites of these insects.

While in civil life the treatment of latent infections due to the tertian and quartan plasmodia differs from that of infections due to the estivo-autumnal plasmodia, in that smaller doses of quinine are used for the former infections, it will be better in the military service to adopt a scheme of treatment that will cure all cases and that can be easily remembered by the individuals concerned. The following treatment of latent infections *in which gametes are not present in the blood*, while it may err upon the side of slightly too much quinine in the case of tertian and quartan malaria will be found efficient in infections due to the estivo-autumnal plasmodia. It should therefore be adopted if a single rule of treatment of all latent cases is to be followed, and this would appear to be the ideal method in the case of troops. This method of treatment is as follows:

Every individual showing plasmodia in the blood (unless *gametes* are present) should receive 2 grams (gr. 30) of quinine daily until the plasmodia have disappeared from the peripheral blood. In most instances this will occur within three or at most four days. After the plasmodia have disappeared quinine should be given in daily doses of 1 gram (grs. xv) for two weeks, and for two weeks thereafter a daily dose of 0.65 gram (grs. x) should be administered. After this the usual prophylactic dose of 0.40 gram (grs. vi) should be given daily for at least two months.

The method of administration as regards time will often depend upon military necessities, but it is best to give the quinine on retiring, or if it can be arranged the larger doses may be divided into equal morning and evening portions. The method may be easily remembered if stated as follows: Thirty grains of quinine daily until the plasmodia disappear, 15 grains daily for two weeks, 10 grains daily for two weeks, and 6 grains daily for two months.

If this method of treating these infections be faithfully carried out, it will be found that latent malaria will disappear and that none of the cases will become *gamete* carriers unless these forms of the plasmodia develop within a day or two of commencing treatment, when the treatment to be advised for destroying these forms should be adopted.

The time to treat latent malarial infection is before the development of *gametes* because these forms are very much more resistant to quinine than are the forms concerned in the human life cycle and because the isolation and screening of the infected individual is necessary while treatment is being pursued if *gametes* are present. Any considerable number of *gamete* carriers in a military post is a reflection upon the treatment of malaria adopted by the responsible medical officer, and is proof positive of the improper treatment of acute and latent malarial infections.

The treatment of "carriers" in the prophylaxis of malaria.—One of the most important, and yet one of the most neglected, prophylactic measures against the spread of malarial infection is the discovery and treatment of "carriers" of the disease. It has already been stated that after a malarial infection has persisted for from 8 to 10 or more days in man, forms of the plasmodia develop that are capable of further development in the mosquito, and that these eventually render this insect infective to man. These forms are called "*gametes*" and they can easily be detected in the blood by microscopic examination. It is obvious that if these *gamete* carriers can be discovered and the *gametes* killed, these individuals will cease to be infectious to the mosquito; but despite this knowledge, this most important method of preventing malaria has been all but neglected, even in the military service. It has been shown that the *gamete* carriers can be rendered harmless by proper treatment with quinine and that it is feasible to employ the drug in this way as a prophylactic against the disease.

Discovery of gamete carriers.—The treatment of *gamete* carriers, or carriers of the malarial infections, depends upon their discovery, and this depends entirely upon the examination of the blood of individuals residing in malarial localities. The control of the treatment of acute and recurrent infections by frequent examination of the blood will prevent their being discharged from hospital before the *gametes*, if present, are reduced to a noninfectious minimum, but there are many individuals in malarial regions who are *gamete* carriers and who have never suffered from marked symptoms of malarial disease. Therefore it is necessary not only to control the treatment of acute infections by blood examinations, but to examine the blood of the apparently healthy if we wish to discover all *gamete* carriers and render them harmless.

The time of occurrence of gametes.—It is universally admitted that *gametes* do not develop in patients who have been properly treated with quinine, and that in untreated cases they do not develop until the infection has presisted for several days. The length of time required for the development of the *gametes* of the estivo-autumnal plasmodia varies from 8 to 15 days, the usual period being about 12 days. In other words, an estivo-autumnal infection must have persisted for nearly two weeks before we can expect to find the crescents, or *gametes*, in the peripheral blood. The *gametes* of the tertian and quartan plasmodia appear in the peripheral blood of man in from 7 to 10 days after the onset of definite symptoms of infection.

Although the time given is based upon the appearance of the *gametes* after symptoms are noted, it should be remembered that these forms are often found in individuals who have never shown marked symptoms of infection, and we may find these forms present on what appears to be the very first day of an obvious infection.

However, in the vast majority of patients, *gametes* do not appear in the blood until several days after the appearance of definite symptoms of malaria, and this fact is of great importance in the prophylaxis of the disease, for proper treatment will prevent their development and thus prevent the infection of the mosquito. The fact is also of significance in explaining the origin of these forms, and would appear to indicate that *gametes* are not introduced into man by the mosquito, but that, as Schaudinn believed, they are differentiated during the human life cycle of the plasmodia as the result of the reaction of the human organism to the parasites, and certainly all the evidence we possess points to this conclusion.

The percentage of individuals showing gametes.—As only those individuals in whom the sexual forms, or *gametes*, occur are capable of infecting the mosquito, and thus, indirectly, of infecting man, it is of interest to know how large a percentage of our malarial patients become "carriers." It may be stated at once, that unless properly treated, practically 80 per cent will probably become capable of infecting the mosquito, but the statistics here given are based upon actual observations.

The number of malarial patients becoming "carriers" will vary, of course, in different localities, owing to conditions favoring the persistence of the infection, the type of infection present, the thoroughness with which treatment is carried out, and perhaps other conditions with which we are yet unfamiliar. This subject has been most carefully studied in the estivo-autumnal infections, and the data we possess show beyond question that the percentage varies greatly and that the incidence of *gametes* in the peripheral blood can not be taken as a true index of their actual occurrence in the body, for in many instances it has been demonstrated that blood obtained by splenic puncture was rich in *gametes* when none could be demonstrated in the peripheral blood. In my own experience *gametes* have been observed in a little over 33 per cent of all the cases of estivo-autumnal malaria whose blood I have examined, but I am convinced that a longer search in the majority of these patients would have considerably increased this percentage. In the instances of recurrent infections in Filipinos, which I have had the opportunity of studying, crescents occurred in fully 80 per cent and were as numerous in the adult Filipino as in the children. Most of these cases had received little or no treatment, and for this reason, I believe, the percentage is practically what would be observed in untreated individuals. From my own observations, I believe that at least this percentage of cases of estivo-autumnal malaria will become "carriers" unless they are properly treated.

We possess but little data regarding the percentage of patients infected with the tertian and quartan plasmodia in whom *gametes* develop, but, in my own experience, I have found that these forms occur in about 50 per cent of the cases of infection admitted to hospital and in about 30 per cent of latent infections.

For practical purposes, an individual who does not show *gametes* in the peripheral blood must be considered as incapable of transmitting infection to the mosquito, but this conclusion should not be arrived at from a cursory examination of the blood but only after the most careful examination of at least two specimens, taken at different times, and, if possible, on different days, for these forms are often numerous in the peripheral blood at one time and practically absent at another.

Estimation of the number of gametes in prophylaxis.—The observations of Darling and Thomson have shown that a certain *number* of gametes must be present in the peripheral blood in order to render the infected individual infective to the mosquito. In a very ingenious series of experiments Darling[53] arrived at the conclusion that the peripheral blood must contain at least 12 crescents per cubic centimeter, *or more than 1 per 500 leucocytes*, in order to be infective to the mosquito, and that patients whose blood contains this number should be regarded as gamete-carriers and kept in hospital until, by the administration of quinine, the number is reduced below this minimum. The number of *gametes* present is easily ascertained by comparing the number with the number of leucocytes counted in a stained smear, properly prepared, and while there may be numerous theoretical objections to this method of estimating the number actually present, I believe that the rule is a safe one to follow in prophylactic work, and that if it were faithfully followed it would result in a great reduction in the amount of malaria in any locality.

The effect of quinine upon the gametes.—No morphological changes have been noted by myself in fully developed *gametes* of any of the species of malarial plasmodia after the administration of quinine, and the observations of Marchiafava, Gualdi, Martirano, Darling, and others, have shown that these forms are capable of development in the mosquito, even though this drug has been administered for weeks in large doses. Therefore the consensus of opinion at the present time is that after the *gametes* of the various species of plasmodia are fully developed quinine has no action upon them, so far as rendering them incapable of developing in the mosquito. This is not true, however, in the early intracorpuscular stages of the development of the *gametes*, for I have observed marked changes in their staining reactions after the administration of quinine which lead me to believe that this drug is capable of injuring them and probably of entirely preventing their development.

The observations of Darling[54] and Thomson[55] have shown that the administration of large doses of quinine, continued over a period of about three weeks, will result in the reduction of the number of *gametes* in the peripheral blood to a noninfectious minimum, i. e., to less than 1 to 500 leucocytes, and, according to Thomson, to less than 1 per cubic centimeter. This reduction is considered by Thomson to be due to the destruction of the asexual parasites from which the crescents arise, but I am of the opinion that it is due to the destruction of the *gametes* themselves, during their early intracorpuscular stages of development, for reasons already noted.

The treatment of gamete carriers in prophylaxis.—The importance, from a prophylactic standpoint, of rendering *gamete* carriers harmless, is self-evident, and the researches of the observers mentioned have shown us how this may be accomplished. No patient suffering from malaria should be returned to duty until a microscopical examination of the blood shows that *gametes* are absent, or at least are present in numbers smaller than 1 to every 500 leucocytes. If these forms are present in a larger number than this, it is necessary to continue quinine in large doses, and both Darling and Thomson, as the result of their very careful observations, state that the drug should be given in doses of 2 grams (grs. xxx) per day for about three weeks before one can expect to reduce the number of *gametes* to a safe margin in the majority of cases they have observed. Of course the dosage may be reduced if the *gametes* are present in small numbers, and Thomson recommends a daily dose of 1.3 grams (grs. xx) for the same period of time in such cases.

The same treatment should be given the *gamete* carriers discovered in making a malarial survey and in whom the infection is latent. In the case of troops, every soldier, who is not in hospital and who shows *gametes* in his blood, should be placed there at once, carefully screened, and treated with quinine in the dosage recommended until his blood shows less than 1 *gamete* per 500 leucocytes. There is no other alternative than the thorough treatment of these "carriers" in camps and posts where anophelines can not be eliminated, and the only way to treat them is to confine them in a screened room and to give quinine in large doses until the blood examination shows that it is safe for them to return to duty. If allowed at liberty, these men furnish a constant source of infection to the remainder of the garrison and render other prophylactic measures less useful than they otherwise would be.

The treatment of *gamete* carriers must be controlled by the frequent microscopic examination of the blood, as in no other way can we be sure when the patient is ready to be returned to duty. Here, again, we see the absolute necessity of every sanitary officer being familiar with the use of the microscope in the diagnosis of malaria and of the morphology of the plasmodia and the methods of demonstrating them.

The treatment of initial and recurrent infections in prophylaxis.— In the preceding discussion of *gamete* carriers it has been shown that the *gametes* do not develop until the infection has lasted for several days; that after they do develop, the patient becomes a "carrier" of malaria; and that in order to render him harmless he must be put upon sick report, confined in a screened room, and given large doses of quinine for practically three weeks. This is absolutely necessary from a prophylactic standpoint, but a still more important prophylactic measure is to so treat malarial infections that the *gametes* do not develop. Every *gamete* carrier is an evidence of either improper treatment or of no treatment, and if of improper treatment, an evidence of ignorance or carelessness on the part of the attending physician. In other words, the proper treatment of the initial attack of malaria would have prevented the formation of *gametes*, and there would have been no "carrier" of the disease. In the prophylaxis of malaria the proper treatment of acute infections is of vast importance, an importance that has not been realized by the profession, and it is sad, but true, that a very large proportion of the malaria present in the majority of localities is directly due to the improper treatment of infections coming under the direct care of the practitioner. The practice of regarding a malarial infection as cured because the symptoms have disappeared is responsible for most recurrences and for the development of "malaria carriers," and it is too often the case that a patient is allowed to resume his work without a blood examination having been made or any directions given regarding the continued use of quinine. Despite the fact that the malarial infections have occupied the attention of the medical profession since the time of Hippocrates, it is not even now impressed with the fact that every such infection is resistant to treatment; that the disappearance of symptoms is no proof that the plasmodia are destroyed; and that a continued course of quinine is absolutely necessary to eradicate even the mildest malarial infection.

The attitude in this respect is very similar to that which obtained in regard to the cure of syphilis prior to the use of the Wassermann test. In both malaria and syphilis specific drugs were known, and if, after the use of these drugs, the symptoms disappeared, the patient was regarded as cured. In the case of syphilis, however, it was recognized that even though symptoms disappeared, from two to three years of constant treatment was necessary before this supposed cure was really accomplished; but in the case of malaria a large proportion of the profession appear to believe that a few doses of quinine, if followed by the disappearance of acute symptoms, signifies the cure of the infection. As a matter of fact, quinine in the treatment of malaria is like mercury in the treatment of syphilis, in that its use must be persisted in for a considerable time after the symptoms of infection have been conquered if one desires to really cure the infection. When this fact is actually realized and acted upon by the medical profession we will witness a great reduction of malaria, because the "carriers" of the disease will be prevented. *The time to begin malarial prophylaxis is with the treatment of every acute infection*, and if this is well done one has performed one of the most important duties, from a prophylactic standpoint, that falls to the lot of the physician. In civil life it may often be impossible to thoroughly treat malarial infections, but in the military service, owing to the absolute control the authorities have over the personel, the proper treatment of malaria is possible and there can hardly be any excuse for its neglect.

The first requisite to the proper treatment of malarial infection is a correct diagnosis, and, in the military service, this should always be made by the aid of the microscope. This may be impossible in the field and the patient may have to be placed at once upon quinine.

but in camps and posts the microscope should be depended upon in the diagnosis of malarial fevers. In this way the exact species of plasmodium is ascertained and there can be no doubt of the correctness of the diagnosis.

Not only should the diagnosis of malarial infection be made by blood examinations, but the treatment of the disease should always be controlled by frequent microscopic examinations of the blood, and no patient should be allowed to leave the hospital until his blood is free from parasites, except where a military emergency exists justifying such action. If this rule be followed the danger from "carriers" of the infection will be very greatly reduced and the surgeon can not be charged with helping along malarial disease by discharging "carriers" from the hospital, while *gametes* are still in the peripheral blood. If only the forms concerned in the human life cycle of the plasmodia are present in the blood, it will be found that they will disappear within a few days after beginning quinine. and then the patient may be returned to duty with directions regardin further treatment; but if *gametes* are present it will mean from two to three weeks of treatment with the dosage of quinine already recommended before they will be reduced to a noninfectious minimum, and the patient can be safely returned to duty.

The *treatment* of initial and recurrent attacks of malarial fever varies with the species of plasmodium present, the tertian and quartan infections requiring less quinine to cure them than the estivo-autumnal infections. It is not my intention to discuss the treatment of malaria here further than to call attention to the method I have found effective in the usual acute and recurrent infections observed in hospital, the reader being referred to the many excellent works upon this subject for information regarding the treatment of pernicious infections. The object of all treatment is to rid the blood of plasmodia as quickly as possible and to cure the disease, and I am no believer in routine methods in the treatment of infections varying so much in severity as do the malarial fevers. It should be distinctly understood that the methods that follow are merely those that I have found most useful in the vast majority of infections that I have had under personal observation and are inserted merely for the purpose of demonstrating the absolute necessity of continued treatment with quinine and of suggesting the way in which the drug may be employed to secure the end aimed at, i. e., the cure of the infection and the prevention of "gamete carriers."

Tertian and quartan malaria.—In these infections, during the acute symptoms, quinine should be given in doses of at least 0.32 gm. (gr. v) every four hours until from one to two grams are given in the 24 hours (gr. xv to xxx), according to the severity of the symptoms, and this dosage continued until the symptoms have disappeared and plasmodia can no longer be detected in the peripheral blood. Thereafter the drug should be continued for at lease three months, the dosage being gradually reduced during the first two weeks of convalescence until the patient takes 0.40 gm. (gr. vi) per day at the end of the second week, and this dose should be continued for at least two weeks longer, and the same dose given twice a week until three months have elapsed from the date of attack. In regions where reinfection is probable, the prophylactic dose of 0.40 gm. (gr. vi) daily, should be adopted at the end of two weeks after the plasmodia have disappeared and kept up as long as required.

Æstivo-autumnal malaria.—In æstivo-autumnal malaria the dosage of quinine must be somewhat increased, as these infections are more resistant to treatment than tertian and quartan infections. In most cases a dose of 0.32 gm. (gr. v) administered every four hours will result in the disappearance of the symptoms within three or four days, but not infrequently cases will be observed that require larger doses. After the symptoms have disappeared 1 gram (gr. xv) should be taken daily for two weeks, and for two weeks thereafter 0.65 gm. (gr. x) should be the daily dose. At the end of this period 0.32 gm. (gr. vi) should be taken daily for at least two months, and as long as required if quinine prophylaxis is necessary.

Patients should only be returned to duty when the peripheral blood is free from plasmodia, or, if *gametes* are present, when they do not number more than 1 to every 500 leucocytes. Before leaving hospital a malaria register should be prepared for each patient, giving the type of infection, the amount of quinine administered, and other data that may be useful or necessary, and upon this register should be entered further treatment after return to duty. Patients should not be allowed to take quinine away with them for self-administration, but should be instructed to report to the hospital at the proper time and the administration of the drug personally attended to by the medical officer in charge of this work. In case of transfer to another organization, the "malaria register" should be sent to the surgeon of that organization and the treatment continued at the man's new station. In this way every malarial patient treated in the Army can be followed and a really scientific prophylaxis of the disease, so far as he is individually concerned, be rendered possible.

The results of quinine prophylaxis.—In concluding this chapter it may be of interest to give a very few illustrations of the efficacy of the quinine prophylaxis of malaria where other methods have failed or have been only partially successful. Without question the most notable instance of quinine prophylaxis is that which has been in operation in Italy since 1905 under the auspices of the Society for the Study of Malaria in Italy, led by Celli. In that country quinine is sold by the State to those able to purchase and distributed free to those unable, and Celli claims that since the gratuitous distribution of quinine by the Government the mortality from malaria in Italy has diminished over 75 per cent and the morbidity in proportion. While other methods of prophylaxis, as screening and drainage, have been used, Celli regards the prophylactic use of quinine as altogether the most efficient, and believes that it is the only method that can be relied upon in Italy to control malaria. In view of the great importance of his work I shall give a brief résumé of the results obtained and his commentaries upon them.

In the following table Celli[56] gives the results of quinine prophylaxis in the army, in which the morbidity has been reduced from 27.4 per cent to about 5 per cent by the use of this method:

TABLE VIII.—*Malaria in the Army.*

Year.	Number of men.	Number of cases (per cent).	Relapses.	Initial attacks.	Remarks.
1902	199,253	27.44	21.41	6.03	No quinine.
1903	206,468	24.14	17.85	6.28	Quinine begun.
1904	210,637	19.21	12.71	6.50	
1905	218,409	21.52	13.04	8.48	
1906	211,245	18.99	12.67	6.32	Quinine.
1907	202,320	12.46	7.96	4.50	Do.
1908	216,679	8.04	5.19	2.85	Do.
1909	228,951	6.96	4.72	2.24	Do.
1910	234,104	5.10	3.23	1.87	Do.
1911	233,517	4.90	3.04	1.86	Do.

From this table it will be noted that there has been a steady reduction in the number of initial attacks and the number of recurrent cases of malaria in the Italian army ever since the adoption of prophylactic quinine, in 1903, until at the end of 1911 the percentage of cases of malaria in the entire army was only 4.9 per cent, and this despite the fact that the troops were often stationed in the most malarious parts of the country.

Celli[57] gives the results of quinine prophylaxis in the penal colony of Castiades in the following table:

TABLE IX.—*Malaria in the penal colony of Castiades, Sardinia.*

Year.	Population.	Quinine used, in kilograms.	Number of cases.	Per cent.	Remarks.
1904	748	None.	694	92	No quinine.
1905	861	13,674	731	84	Little quinine.
1906	807	15,080	390	48	Quinine.
1907	795	40,230	132	16	Daily quinine distributed.
1908	700	35,400	97	13	Do.
1909	691	32,000	64	9	Do.
1910	655	15,280	139	19	Only curative quinine.
1911	540	25,360	37	6	Prophylactic quinine.

In regard to this really remarkable reduction in the number of cases of malaria among the prisoners in this institution from 92 per cent to 6 per cent, Celli says:

> It was the prophylactic administration of quinine alone that produced the miracle of diminishing malaria to 8 or 9 per cent.

In the whole of Italy the mortality from malaria has decreased from 21,000 deaths in 1887 to about 3,000 in 1908, quinine prophylaxis having been established about 1905, and Celli says:

> Beyond doubt the greatest and most persistent decrease of mortality from malaria in Italy was due to the increased consumption of quinine.

In view of these results it is useless for the opponents of quinine prophylaxis to claim that it is of little value in the prevention of malarial infections, for they absolutely demonstrate that the method, if faithfully followed, is of the very greatest service, and similar results have been obtained by other observers.

In the Dutch Indies, Bisdom[59] has reduced the percentage of Europeans infected from 80 to 20 per cent, and the percentage of infections in natives from 71 to less than 17 per cent, by the use of quinine in prophylaxis and treatment, and states that the use of this drug has been the most important factor in diminishing the incidence of malaria in the Netherland Indies. In Corsica,[60] Leger has found quinine prophylaxis very effective, the blood index among the inhabitants of Casabianca, for example, falling from 42.85 per cent to 7.14 per cent after the exhibition of 0.20 gram of quinine daily, and the Sergents[61] have reported excellent results in Algeria.

The impression that quinine prophylaxis must extend throughout the year in malarial regions is erroneous, for in almost every locality there is a malarial season, and it is only just prior to and during this period of seasonal prevalence that it is necessary to use the drug in this manner. Prophylaxis with quinine should be begun about a month before the malarial season begins and continued for about the same time after it ends. In some localities, of course, the drug will have to be given the greater part of the year, but in most places it will be found that it can be omitted for weeks, or even months, with advantage.

In conclusion, it may be stated that in quinine prophylaxis we possess a most valuable method of preventing malarial infections, and one that can be easily applied in the military service, but it should not be used to the exclusion of the more permanent methods depending upon the destruction of the mosquito,where such methods can be instituted. Although, as Celli says,[62] "those who take quinine daily, having a certain quantity of it in the circulating blood, can fearlessly subject themselves to the inoculation of blood loaded with hæmosporidia, and, with much less danger, to the biting of infected anopheles," the method requires the most careful supervision, is more or less disagreeable to the individual, and is less permanent than the abolition of breeding places of the insects transmitting the disease. In the military service its greatest use will be found in the protection of troops in active operations in the field in malarial regions, and as an aid in the prophylaxis of the disease in camps and posts in conjunction with the other prophylactic measures described.

Chapter VI.

THE APPLICATION OF THE METHODS OF MALARIA PROPHYLAXIS TO THE MILITARY SERVICE.

In the following chapter a brief summary will be given of the methods of malaria prophylaxis which have been discussed and the manner in which they may be utilized in the prevention of the disease in the military service. The fact that troops are under strict discipline makes it possible to more thoroughly apply prophylactic measures in the Army than is often the case in civil life, and for this reason better results may be expected when such measures are faithfully and intelligently carried out. The great reduction in malaria in the Army already noted is proof of this statement, and there is no reason why these infections should not be still further reduced. and eventually disappear in our permanent posts if prophylactic measures are continued.

As has already been stated, the prophylaxis of malaria requires very different methods in the field than in semipermanent camps and permanent posts, and in all situations the methods employed will vary according to local conditions and military exigencies. This fact must be recognized by every practical sanitarian, and in the following discussion regarding the application of malaria prophylaxis to the military service it should be remembered that the suggestions offered are merely suggestions, which may or may not be practical in actual service owing to the peculiar conditions surrounding each prophylactic problem.

Malaria prophylaxis in the field.—The necessity for malaria prophylaxis in the field during the active operations of an army should have been ascertained before the invasion of the country with which hostilities are being conducted. This presupposes the accurate mapping of the country from a sanitary standpoint, a hitherto much neglected branch of military information. In the past an accurate knowledge of malarial localities would have saved many armies an enormous loss from this cause, as campaigns could have been planned so as to avoid exposing troops to these infections, and the most exhaustive knowledge of terrain is of little use if troops are so decimated by malarial infection as to be unable to take advantage of such knowledge. An accurate sanitary map showing the prevalence of disease in the country to be invaded would be of great value in the planning of any campaign, as in the majority of instances it would be found that badly infected districts could be avoided without damage to the campaign from the military point of view, or prophylactic measures could be instituted in time and prevent the infection of the Army.

In active operations in the field we must depend for the prevention of malaria upon the prophylactic use of quinine and the use of the mosquito net. Quinine sulphate should be given in daily doses of not less than 40 centigrams (gr. vi), preferably administered in 20 centigram doses morning and evening. In many and perhaps the majority of instances it may be found that the entire dose must be given at one time, and if so it is best to give it in the evening. The men should be assembled at a convenient time and the quinine administered by a medical officer, care being taken to see that each soldier swallows his dose. The quinine may be most conveniently carried and dispensed in tablet form, but the utmost care should be taken to see that the tablets are readily soluble.

If acute attacks of malaria develop in the command it will be found best to send the men disabled to the nearest field hospital, where the type of infection can be ascertained and properly treated, or, if necessary, the patient may be sent to the base hospital for treatment. After the plasmodia have disappeared from the blood the men may be returned to duty, but not before. Nothing will be gained by keeping men suffering from acute attacks of malarial fever with an advancing column, as they will only encumber it and may prove a source of infection to their companions.

In all regions in which mosquitoes occur the Vedder mosquito net should be used in the shelter and other tents, and inspections should be made by medical officers in order to see that the net is being properly used. Guards should wear head nets and gloves, and both the mosquito nets and head nets should be inspected frequently for tears or holes and promptly repaired.

It is believed that with an efficient enforcement of the use of nets and of prophylactic quinine an army will be able to campaign in the most badly infected malarial districts without suffering very greatly from the infection. These methods will not prevent all infection, but may certainly be trusted to prevent the vast number of infections which would otherwise occur, and which, in times past, have rendered entire armies useless as fighting machines. If such methods had been efficiently carried out at Santiago it is safe to say that malaria would not have placed our Army in such a position that retreat was actually considered.

Malaria prophylaxis in semipermanent camps.—The first and best step in the prevention of malaria in camps of short duration is the selection of a region free from malaria as the camp site. Here again the value of a map showing such regions is evident, but in its absence, and, if time and military contingencies permit, much may be learned in a short time by observations of the kind of mosquitoes present, the location of their breeding places, and an examination of the blood of from 20 to 40 children and adults in the region being investigated. This entire study of a location need not consume more than a few hours and will generally result in definite knowledge regarding the prevalence of malarial infection. If, despite the presence of infection, the locality must be selected for a camp site, the measures pursued will vary, of course, with the length of time the camp is to be occupied and the facilities afforded for their execution.

If the camp is to be occupied for only a few days, the prophylactic use of quinine, the use of the mosquito net, and the clearing of an area from 100 to 200 yards around the camp of long grass and underbrush will be about all that can be done in the way of prevention.

In the case of camps that will probably last for several months and are, therefore, of semipermanent character, the same precautions should be taken regarding the selection of a site as recommended for permanent posts, and similar prophylactic measures should be employed if malarial infection appears.

Malaria prophylaxis in permanent posts.—Before establishing a permanent military post in the tropics or in regions in which the presence of malarial infection is suspected, a malaria survey of the locality is of the greatest importance, and, in most instances can be made without interfering with military movements. If such surveys had been made before certain posts were established in the Philippines, it is probable that other localities would have been selected with a resultant saving in money and efficiency. Certainly there can be no excuse for establishing a military post in a very malarious region when a malaria survey would have shown that adjacent regions were free from the infection and when there was no military necessity for occupying exactly the locality chosen.

The following points should be considered in estimating the safety of a locality as regards malaria when the question of choosing it for the site of a post is considered: The statistics regarding fevers in the locality, if there are any, should be studied; the character of the soil and the nature of the terrain; the species of mosquitoes present; the breeding places of mosquitoes and the kind of larvæ present; the presence and number of infected mosquitoes; and the number of latent infections in children and adults. A map of the locality should be obtained, or prepared, and the entire region districted, after which a careful investigation regarding the points mentioned should be made of each district by a trained medical officer. Upon the map should be marked the location of breeding places of mosquitoes, the species found in each breedery, and whether any of the insects examined were found infected with plasmodia. In addition the dwellings of individuals found infected with malaria during the blood examinations of the inhabitants should be indicated on the map, thus showing the relation of breeding places to such infections. The map should also show the ratio of infected individuals and mosquitoes and the most severely infected districts. The work of a few days in the examination of the blood of the inhabitants, the dissection and examination of mosquitoes, and the location of breeding places of anophelines will result in a most valuable mass of data, enabling one to judge of the advisability of locating a post in the region investigated, and what methods would be best adapted to ridding the region of malarial infection. Such a malaria survey is just as important to the future health of the command as the question of an adequate and pure water supply.

In posts that are known to be malarial the prophylactic methods adopted must vary with local conditions, and the best way to become acquainted with these conditions is to make a malaria survey, just as one would in deciding upon the location of a site for a permanent post. The post should be districted upon a map and a most careful search made for the breeding places of mosquitoes, while, coincidently, the species of mosquitoes present should be ascertained and the ratio of infected insects. An examination of the blood of at least 40 adults and children living in the immediate vicinity of the post should be made, as well as of the same number of soldiers in the post, in order to ascertain the presence of latent infection, and the records of the post should be consulted as to the prevalence of malaria during the past. As soon as this preliminary survey is completed one will have data upon which to work out the best method or methods of prophylaxis for the particular locality investigated. While in rare instances it will be found that mosquitoes can be exterminated and that this is the only prophylactic measure that need be adopted, in the vast majority of posts the malarial problem is best attacked by using all the methods at our command. These consist in the abolition of the breeding places of mosquitoes and their destruction in the adult stage by trapping and catching by hand, the protection of the command from their bites by screening and the use of nets, and the destruction of the plasmodia by quinine. The latter method may be omitted, so far as the healthy population is concerned, provided malarial infection is not very intense and the other methods mentioned will control the situation, but in badly infected posts, where it is impossible to get rid of mosquitoes, quinine prophylaxis should be adopted during the malarial season.

Every effort should be made to rid the post and the surrounding country for a distance of at least 2 miles of breeding places of anophelines. Very often the most that can be done is to reduce their number, owing to the immense cost of drainage and filling in, but as much should be done as possible, however gloomy the outlook. If mosquitoes are very numerous they can be greatly reduced by mosquito traps and by detailing men for the purpose of catching the insects by hand, as is done in the Canal Zone, where this method has met with really remarkable success.

It is unnecessary to state that every post in which anophelines can not be eradicated and where malaria prevails should be thoroughly screened, and yet the cost of this procedure has prohibited its adoption in some of the most malarious posts occupied by the Army, until quite recently. The economy which forced the omission of this very important prophylactic measure was in reality an extravagance, for the loss of time and money occasioned by the malarial infections in the troops was much more costly in the end than the amount involved in the purchase of proper screening material. Barracks, quarters, and other buildings should be screened with the best copper netting of not less than 16 meshes to the linear inch, and, where the yellow-fever mosquito is present, of 18 meshes to the linear inch.

The use of the mosquito net for the bunk should be rigidly enforced unless quarters and barracks are screened, and a nightly inspection should be made to see that the men are using the nets properly. The head net and gloves should be worn by soldiers on duty in the late afternoon and during the night in all posts where malaria is prevalent to any extent.

All shelter for mosquitoes in the post and for a distance of 300 yards outside the post limits should be reduced to the minimum, and the utmost care should be taken that no small breeding places, such as are furnished by unused hoppers, rain barrels, tin cans, and small pools due to improper drainage, exist in the post.

The prophylactic use of quinine should be enforced if malaria is prevalent enough to warrant it, and daily doses of 0.40 centigrams (gr. vi) should be administered under the personal observation of a medical officer. In most posts in which malaria occurs this will not be found essential in the control of malaria, *if "carriers" be discovered and treated and all acute and recurrent cases of malaria be kept in hospital until the plasmodia disappear from the blood under quinine and if treatment be continued in the manner already described.* In the Tropics, however, where the soldiery is continually coming in contact with a badly infected native population, the use of quinine prophylaxis should be insisted upon during the malarial season.

If natives in whom there is a large percentage of latent infection and many "carriers" live around the post, it would be an economical measure for the Government to issue them free quinine, to be distributed and administered by a medical officer. In many instances this measure alone would practically eliminate malaria from among the troops, because it would remove the greatest source of infection of mosquitoes and, indirectly, of the command.

The discovery and treatment of latent malarial infections and of "carriers" in the command is a most important prophylactic duty, which should never be neglected in posts where the disease is prevalent. This involves, of course, the microscopical examination of the blood of all members of the command, and, in badly infected regions, this examination may have to be repeated at monthly intervals, although the prophylactic use of quinine should render this unnecessary after the first examination has been made. In a large command such an examination may be impracticable, but in smaller posts the measure is practical and, although it involves a great deal of work, should be followed out where malaria is really a serious problem.

Every patient admitted to hospital for malaria should have the diagnosis confirmed by the microscope, if possible, and treatment should be controlled by a daily examination of the blood. No patient should be discharged from the hospital until the peripheral blood is free from plasmodia except in the case of *gamete* carriers, who may be returned to duty when the gametes are reduced to less than 1 to 500 leucocytes.

A "malaria register" should be prepared for every patient, upon which should be entered the type of infection, the treatment given in hospital and ordered after leaving the hospital, the date when the plasmodia disappeared from the blood, the date of return to duty, and any other information that may be thought desirable. When transferred to another command, the malaria register should be sent to the surgeon of the post, who can then continue the treatment.

Every patient returned to duty should be directed to report at a certain time for quinine in continuance of the treatment, and the quinine should be administered under the personal supervision of a medical officer, if possible. The time of reporting can be so arranged as to be convenient for all concerned, and each dose administered should be entered upon the man's "malaria register."

When soldiers suffering from latent malarial infections are discovered they should be placed in hospital and a most careful examination be made relative to the presence of *gametes* in their blood. If *gametes* are not present, they should be returned to duty as soon as the blood is free from plasmodia, with directions to report for further treatment; but if *gametes* are present, the patients should be treated in hospital until the *gametes* are reduced to less than 1 per 500 leucocytes. The method of treating these cases has already been discussed in Chapter V. A "malaria register" should be prepared for these cases and used in the same manner as for acute and recurrent infections, but the fact that the case is a latent one should be entered upon the register.

The suggestions given above for the prophylaxis of malaria in the field, in temporary camps, and in permanent posts, do not cover all that may be done along this line, but may serve as a guide in the prevention of these infections in the military service. The aim of the medical officer should be to do all in his power to prevent the transmission of these infections, but the methods to be adopted will vary, of course, with special conditions, and it will often be possible to control the disease without resorting to all of the methods that have been described. However little he may be able to do in the way of eradicating mosquitoes, he has absolute control over patients in hospital, and can see that no man who has been in the hospital for malaria is returned to duty until he has ceased to be a source of danger to his companions. He can also insist upon the continuance of quinine until there is a reasonable surety that the infection is cured, and thus prevent the recurrences which furnish the majority of malarial cases in any hospital.

In conclusion, it may be stated that the malarial fevers are entirely preventable and their presence, to any extent, in an army post is a reflection either upon the intelligence of the sanitary officer in control, or upon that of other authorities who, either by indifference to the recommendations of the sanitary officer or unwillingness to supply the necessary funds, have rendered the efforts at prophylaxis futile.

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WAR DEPARTMENT :: OFFICE OF THE SURGEON GENERAL

BULLETIN No. 7

SEPTEMBER, 1914

STUDIES IN ROENTGEN-RAY DIAGNOSIS

WITH ESPECIAL REFERENCE TO THE GASTRO-INTESTINAL TRACT

BY

A. C. CHRISTIE
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PREFACE.

In the sundry civil act for 1913, under the appropriation for printing and binding for the War Department, it was provided:

> That the sum of $3.000, or so much thereof as may be necessary, may be used for the publication from time to time of bulletins prepared under the direction of the Surgeon General of the Army for the instruction of medical officers, when approved by the Secretary of War.

Similar provision was made in the sundry civil act for 1914, and it is hoped that this appropriation will be continued from year to year in the future. It is intended that these bulletins shall be used for the publication to the Medical Corps of the special technical work of the service laboratories, the reports of the boards for the study of tropical diseases, and other work of medical officers which is of too special or technical a character to make it acceptable for publication in the medical journals and the military surgeon.

The bulletin will be published, if possible, at least quarterly. Officers of the corps are requested to submit suitable articles to this office for use in the bulletin, with the understanding that they may be published elsewhere by the author if found not suitable for the bulletin.

Chas. M. Gandy,
Acting Surgeon General United States Army.

September 24, 1913.

ORDER.

A board of officers of the Medical Corps, representing the sanitary and statistical division and the Library of the Surgeon General's Office and the laboratory of the Army Medical School, is hereby convened for the purpose of collecting materials and arranging for the publication of the bulletins for the instruction of medical officers authorized by the act approved June 23, 1913.

Detail for the board:

Lieut. Col. Champe C. McCulloch, jr.
Maj. William J. L. Lyster.
Maj. Eugene R. Whitmore.

Chas. M. Gandy,
Acting Surgeon General United States Army.

LIST OF ILLUSTRATIONS.

FIGS. 1 to 4. Types of normal stomach.
FIGS. 5 to 8. Types of normal stomach and cap.
FIG. 9. Perforated gastric ulcer.
FIG. 10. Perforated gastric ulcer with incisura.
FIGS. 11 and 11a. Same case as Fig. 10 after operation.
FIG. 12. Gastric ulcer with incisura.
FIG. 13. Gastric ulcer with incisura.
FIG. 14. Gastric ulcer with incisura.
FIG. 15. Deformity of stomach due to adhesions resulting from ulcer.
FIG. 16. Same case as Fig. 15 after gastro-enterostomy.
FIG. 17. Dilatation of stomach due to pyloric obstruction.
FIG. 17a. Six-hour residue in same case as Fig. 17.
FIG. 17b. Same case as Fig. 17 after gastro-enterostomy.
FIG. 18. Gastric carcinoma.
FIG. 19. Large carcinoma of pyloric end of stomach.
FIG. 20. Small carcinoma at pylorus.
FIG. 21. Large carcinoma at pylorus.
FIG. 22. Large infiltrating carcinoma of stomach.
FIGS. 23, 23a, b, c. Gumma of stomach.
FIG. 24. Gallstone.
FIG. 25. Linitis plastica.
FIG. 26. Distortion of duodenal cap by adhesions.
FIG. 27. Lane's kink.
FIG. 28. Obstruction in terminal ileum.
FIG. 29. Ileo-cecal regurgitation.
FIG. 30. Dilatation of cecum and hepatic flexure caused by obstruction due to Jackson's membrane.
FIG. 31. Adhesions about colon causing partial obstruction.
FIG. 31a. Same case as Fig. 31, after operation.
FIG. 32. Fixation and angulation of cecum due to adhesions.
FIG. 32a. Same case as Fig. 32, after operation.
FIG. 33. Adhesions about cecum ascending colon, and proximal part of transverse colon.
FIG. 34. Deformity of cecum caused by adhesions.
FIG. 35. Adhesions about cecum, terminal ileum, and proximal part of transverse colon.
FIG. 35a. Same case as Fig. 35, 24 hours after bismuth meal.
FIG. 35b. Same case as Fig. 35, 48 hours after bismuth meal.
FIG. 36. Pressure of tumor (cystic kidney) on hepatic flexure.
FIG. 37. Reduplication and fixation of folds of colon near hepatic flexure.
FIG. 38. Transverse colon adherent to sigmoid. Prone position.
FIG. 38a. Same case as Fig. 38. Erect position.

Fig. 38b. Same case as Fig. 38. Trendelenburg position.
Fig. 39. Obstruction at cardiac end of stomach with dilatation of esophagus.
Fig. 40. Brass rivet in upper part of esophagus.
Fig. 41. Porcelain headed pin in small intestine.
Fig. 42. Long sigmoid adherent to descending colon.
Fig. 43. Appearance of colon in spastic constipation.
Figs. 44 and 44a, b, c, d, e, f, g, and h. Series of roentgenograms of cyst of femur with fracture.
Figs. 45 and 45a. Brodie's abscess, left tibia.

INTRODUCTION.

This bulletin has been prepared especially to make permanent record of many interesting and instructive gastrointestinal cases which have been studied in the roentgenological laboratory of the United States Army Medical School. Roentgenograms of a few cases other than gastrointestinal having some special interest have been added. Nearly all of the cases reported here have had the X-ray findings checked either by operation or autopsy. It is so stated under the case report if the diagnosis was established in some other way.

For the sake of making the work complete it is thought best to give a short account of the gradual evolution of the present methods of roentgenological examination of the gastrointestinal tract and to describe the method used in examination of the cases reported here. A short description is also given of the signs which have been proven of value in diagnosis of various gastrointestinal lesions.

STUDIES IN ROENTGEN-RAY DIAGNOSIS.

HISTORY—METHODS OF EXAMINATION.

The X ray was first used to study the movements of the gastrointestinal tract in animals by Cannon, of Boston, in 1896. Bismuth subnitrate was used as the opaque medium to render the tract visible. The present method of examination in man was instituted by Rieder, of Munich, in 1904. The subnitrate of bismuth was soon found to be toxic in the large amounts used and has been supplanted by other salts. The most commonly used salt at the present time is bismuth subcarbonate. Barium sulphate is rapidly gaining in favor and has the advantage of being much cheaper than bismuth. Several firms now prepare barium sulphate especially for X-ray work, and one should always so specify when ordering it. It is necessary to use it in a little larger quantities than bismuth, but even so the cost is materially less.

The following procedure has been used in the examination of the cases whose histories are recorded in this bulletin. The patient presents himself for examination without any special preparation, the aim being to examine him in as nearly his usual condition as possible. Three ounces of bismuth subcarbonate is mixed with 8 ounces of buttermilk. The patient then stands in an upright fluoroscope with his right hand behind his head and the right anterior part of his chest pressed snugly against the fluorescent screen. While the operator is observing the shadow on the screen the patient takes the glass containing the bismuth meal in his left hand and drinks slowly, the observer carefully noting any unusual delay or deviation in the passage of the bismuth and buttermilk through the esophagus. The patient then turns so that the anterior part of the abdomen is against the screen and the stomach is observed for a moment to detect any abnormalities of shape, position, motility, or mobility. One roentgenogram is then made in this position. He now lies horizontally upon a table with abdomen next to it, a pillow being placed under the chest and another under the hips to avoid undue pressure upon the stomach. A series of plates varying in number from 6 to 12 is now made. One or two plates are also taken with the patient turned somewhat obliquely in order to get a shadow of the posterior wall of the stomach. No further examination is made until six hours later, when one plate is taken to determine whether or not there is any residue in the stomach. The patient should fast from the time the bismuth meal is taken until after the six-hour picture, since mixture of food with the bismuth meal will cause delay in emptying of the stomach.

The next examination is made 24 hours after ingestion of the bismuth, when the colon is usually found fairly well outlined. For this examination the patient stands in the fluoroscope, and by manipulation it can be determined whether or not there is any unusual fixation of the colon. One plate is made at this time for record. To make the study of the colon complete, it is necessary to fill it with an enema of some opaque material. This can be conveniently done at the 24-hour examination, the bismuth still present from the meal offering no material objection to this. The enema is prepared by mixing 6 ounces of barium sulphate with 1½ liters of luke-warm water and adding 1 ounce of powdered gum acacia to hold the barium in suspension. This mixture is placed in a fountain syringe and suspended about 3 feet above the table on which the patient is to lie. It has been found entirely unnecessary to use a rectal tube, since the colon is readily filled by using a common hard-rubber rectal tip. The patient lies upon his left side and the suspension is allowed to flow slowly into the bowel. When it has all entered he turns upon the abdomen, the plate is placed beneath him, and the exposure made. He then arises and stands in the upright flouroscope to enable the examiner to again examine the colon for points of fixation or constriction. One plate is taken in this position. If anything unusual is found in the colon, it is well now to make stereoroentgenograms because they assist greatly in deciding upon the presence or absence of kinks or constrictions. The examination is now complete unless some special abnormalities have been discovered which require verification or further study.

Plates 10 by 12 inches have been found the most convenient size for stomach work and 14 by 17 inches for the colon.

STUDY OF CASES.

None of the esophageal cases studied in this laboratory have come to autopsy and for this reason no case histories are presented here. A few roentgenograms are reproduced showing esophageal obstruction.

THE STOMACH.

The normal stomach varies greatly in size, shape, and position. The best classification is probably that based upon muscular tone. (Figs. 1–4). The orthotonic stomach grasps its contents and maintains its tubular shape with the patient erect. The hypertonic variety is the so-called "steer-horn" shape, lying high in the epigastrium and more or less horizontal. This form is scarcely ever seen in women and usually only in men of well-developed musculature. In the hypotonic form the vertical part of the stomach has lost its tubular shape, much of the meal having settled to the lowest part. In the atonic stomach the meal gravitates to the most dependent portion, little or none remaining in the vertical part. In determining the emptying time of the stomach its tone must be taken into consideration. Six hours is considered a liberal limit for the stomach to become completely empty, but in an atonic stomach it may take at least eight hours.

The first part of the duodenum, known as the duodenal cap, is important from a roentgenologic standpoint. Constant variations in its contour may furnish evidence of various abnormalities. Figures 5–8 show roentgenograms of the stomach and duodenal cap which may be considered entirely normal.

Ulcer of the stomach.—The Roentgen ray has become of great assistance in the detection of gastric ulcer, in many cases not only furnishing positive evidence of its presence but also giving information as to its position and extent. Two varieties of ulcer may be positively diagnosed by the X ray. These are the penetrating ulcer with deep crater and the perforating ulcer with cavity formation. Figure 9 shows a perforating ulcer about the middle of the lesser curvature, the bismuth having entered the cavity outside of the stomach. Figure 13 shows evidence of a penetrating ulcer on the upper third of the lesser curvature with a deep incisura opposite to it. It is often necessary to use the greatest care in order to visualize the "niche" of the penetrating or the cavity of the perforating ulcer, since it may be located posterior to the stomach, and hence invisible in a posteroanterior view. The stomach should always be viewed in an oblique direction with the right anterior part of the abdomen against screen or plate, in order to visualize abnormalities on the posterior wall.

There are other roentgenologic signs of great value as corroborative evidence of the presence of ulcer, although not diagnostic in themselves. These are the incisura (figs. 10, 11, 12, and 14), the six-hour residue, hourglass stomach, and localized tender point on pressure.

The incisura is an indentation of the wall of the stomach occurring opposite to an ulcer. It practically always occurs on the greater curvature opposite to an ulcer of the lesser curvature. As a sign of gastric ulcer it ranks next in importance to the positive diagnostic signs mentioned above. Care must be taken not to confuse the incisura cardiaca occurring in normal stomachs under the left costal margin or the incisura angularis occurring in the angle of the lesser curvature with true incisurae. Very typical looking incisurae may also be caused by reflex irritation, such as appendix or gall-bladder disease. To be of value as a diagnostic aid, the incisura must be constant in position and accompanied by other signs of ulcer. The cause of the incisura is thought to be the spasmodic contraction of the circular muscular fibers of the stomach as a result of the irritation of the ulcer. The edges of a true incisura are usually quite smooth and its extremity bluntly rounded. The occurrence of two ulcers close together, however, may give it a ragged appearance. It may vary in depth from a mere nick to such a depth as to produce almost an hourglass appearance. Although the true incisura is constant in position it is not constant in depth. This would naturally be expected, since its cause is a spasmodic contraction of the muscular fibers.

A marked residue in the stomach at the end of six hours, amounting to one-eighth or more of the meal, is considered a confirmatory sign of ulcer. The pylorospasm which usually accompanies ulcer is supposed to be the cause of the delay in emptying. There are other causes, however, of slow evacuation of the stomach which must be taken into account, such as carcinoma, obstruction in the duodenum from various causes, obstructive adhesions from cholecystitis, and reflex spasms of the pylorus caused by conditions elsewhere in the abdomen. It is obvious that the tone of the stomach must be taken into consideration in judging the significance of a six-hour residue. A residue which has no significance at all in an atonic stomach might be of great importance in one that is hypertonic. If interpreted in the light of other findings the six-hour residue is of value as a diagnostic sign. The presence of a well-marked incisura, for instance, accompanying the six-hour residue is considered quite positive evidence of the presence of ulcer.

The hour-glass stomach has about the same value in diagnosis of ulcer as the incisura, since it usually has the same cause—a spasmodic contraction due to irritation. This condition may, however, be organic, due to extensive adhesions after ulcer which has perforated. The hour-glass stomach caused by carcinoma has fairly characteristic indentations which will be described later.

A *localized pressure tender spot* must be very sharply circumscribed, constantly present, and accompanied by other signs of ulcer in order to be of value as a diagnostic aid.

All of the roentgenologic signs of ulcer are less easily demonstrated near to the pylorus and in the duodenal cap. For this region Cole's method of serial reontgenography is of especial value. The only objection to its use is the large number of plates used, but the writer has found that information can be gained about the condition of the pyloric end of the stomach and of the duodenum which it is very difficult or impossible to obtain in any other way. The method consists in taking 10 or 12 plates in rapid succession (as rapidly as one can be substituted for another) with the patient prone. Five or six plates are then made in an oblique or lateral position and the same number with the patient erect. To minimize the cost of this procedure 8 by 10 plates may be used. When the plates are finished they are placed side by side in an illuminating box in the order in which they were exposed and carefully compared. Certain small defects in the bismuth shadow constantly present in all of the plates can be quite accurately interpreted as caused by various conditions, such as scar from ulcer, or adhesions due to ulcer or cholecystitis. Good plates are necessary, and much care and experience must be exercised in utilizing this method; but, as stated above. it is a very useful one in lesions about the pylorus.

In interpreting appearances about the antrum pylori and of the cap one must take care to distinguish those deformities due to spasm. Spasmodic contractions causing almost complete obliteration of both antrum and cap may be induced by a variety of causes. Among these are chronic appendicitis, gall-bladder disease, and either gastric or duodenal ulcer, especially if perforated. Serial roentgenography has an advantage here since if even one plate shows an antrum and a cap normal in contour it is evident that the deformity is caused by spasm.

Gallstones sometimes throw a shadow upon the plate from which a diagnosis of their presence may be made. Case estimates that they may be detected in about 50 per cent of the cases in which they are present. (Fig. 23.)

Carcinoma of the stomach, if at all advanced, gives a very characteristic roentgenographic appearance. The evidence is that of an irregular growth encroaching upon the gastric lumen. (Fig. 18.) If the tumor is near to the pylorus it may cause obstruction with consequent enlargement of the stomach. (Figs. 20 and 21.) There are other cases in which the stomach is very small (Fig. 22), due to general infiltration of the walls. This general contraction of the stomach may also be caused by the condition known as linitis plastica. (Fig. 25.) Often a small cancer at the pylorus will be accompanied by very rapid emptying of the stomach as a result of the infiltration and stiffening of the pyloric walls.

Gumma of the stomach may be mistaken for carcinoma, since the roentgenologic findings are practically identical. (Figs. 23 and 23a, b, and c.)

THE SMALL INTESTINE.

Adhesions about the first part of the duodenum or duodenal cap have already been mentioned. Figures 15 and 26 show roentgenograms of cases in which diagnoses were correctly made of adhesions involving the gall bladder and cap.

Obstructions in the duodenum and other parts of the small intestine are shown by the collection of the bismuth proximal to them. The second and third parts of the duodenum and the entire extent of the jejunum yield very little information to roentgenologic investigation because of the rapidity with which the bismuth meal passes through them.

Stasis in the ileum has received much attention during the past few years. The presence of this condition can be determined by roentgenologic study. Usually when the patient returns for the 24-hour examination the ileum is empty. If there has been no undue delay in evacuation of the stomach the presence of bismuth in the ileum at the end of 24 hours is an evidence of ileac stasis. Its degree can be determined by later examinations. Very often the cause of the stasis can be discovered, such as Lane's kink or adhesions about the cecum and terminal ileum. (Figs. 27 and 28.)

Incompetence of the ileo-cecal value is present in a considerable percentage of cases receiving the barium enema, as shown by the filling of the ileum and sometimes even of the jejunum. (Fig. 29.) The writer has been unable to associate these cases with any particular symptomatology, some of them indeed appearing quite normal.

THE COLON.

The colon varies even more than the stomach in size, position, and mobility. It gradually diminishes in diameter from the cecum to the sigmoid.

The *cecum* shows great variations in size, in some cases being widely dilated and in others contracted. The dilatation may be due to adhesions or pericolonic membranes above the cecum, causing obstruction, or to an atonic condition. A small contracted cecum may be caused by adhesions about it following appendicitis or cecal inflammation independent of the appendix, or to an investing membrane.

The mobility of the cecum and other parts of the colon may be determined by palpation during the screen examination. The cecum is often abnormally fixed by adhesions or congenital membranes, the fixation tending to produce cecal stasis. On the other hand, it is sometimes abnormally movable (cecum mobile). In the latter case it is also usually dilated and atonic. Other parts of the colon may also be fixed or reduplicated in an unusual manner so as to offer obstruction to the passage of its contents. Ptosis of the transverse colon is a very common finding, but probably causes little trouble to the patient unless some part of the ptosed viscus is fixed in such a way as to cause obstruction. (Figs. 33 and 38.)

There has been considerable speculation as to the manner of origin of the various membranes and adhesions about the cecum and other parts of the colon, whether they are congenital or of inflammatory origin. The general view now seems to be that many of the veils and membranes are probably congenital, but that the presence of these may at some time determine a certain amount of fecal stasis with consequent infection which produces a localized colitis. The colitis causes the production of further adhesions, which in turn increase the tendency to fecal stasis, a "vicious circle" being formed.

The sigmoid is sometimes long and redundant and may be adherent in the region of the appendix or in almost any other part of the abdomen. Case reports a case in which the sigmoid was adherent to both a diseased appendix and to the gall bladder. Figure 42 is that of a case in which the sigmoid is adherent high on the left side of the abdomen.

New growths of the colon may be quite accurately diagnosed by X-ray study. Figure 36 shows roentgenogram with defect in colonic shadow, due to pressure of tumor from without.

Spastic constipation may be diagnosed from the appearance of the shadow of the colon following a bismuth meal. The appearance is that shown in figure 43.

CASE HISTORIES.

CASE 1. Mr. G. E. W. Age, 55. Date, December 31, 1913. (Fig. 9.)

History.—Came under observation of Dr. J. R. Verbrycke on December 26, 1913. Has suffered from indigestion for four years. Two years ago diagnosis of gastric ulcer was made; had hematemesis at that time. During past four years has lost about 60 pounds in weight. Complains of pain in left side of epigastrium running downward. Also has hunger pain at times, which is worse at night. Gas and fullness. Bowels constipated and had passed tarry stools two days ago. One day in October had been suddenly thrown to floor with violent pain in upper abdomen. Recovered from this attack and went to work again next day.

Physical signs.—Pulse rapid and intermittent; apex beat in eighth interspace, nipple line. Blood pressure, 170. Splashing sound entirely on left side of abdomen. Localized point of tenderness in midepigastrium and a more marked one just below costal border in left side of epigastrium. Indefinite feeling of mass over left side of epigastrium. Did not pass stomach tube because of condition of heart. Vomitus, about 200 c. c. in amount, brownish, acid, containing many leucocytes and yeast cells; one food particle from night before. Occult blood faint. Acidity, 36 and 46. Thread test negative (did not pass pylorus). Patient put to bed until December 31, without improvement.

Roentgenological examination.—December 31, 1913. Stomach large and atonic. Small amount of bismuth outside of stomach about middle of lesser curvature. Partial hour glass condition.

Diagnosis positive of perforated gastric ulcer.

Operative findings.—Operation by Dr. C. S. White January 5, 1914. Large inflammatory mass in hollow of lesser curvature about half size of egg. Adhesions about perforation were very firm and were left undisturbed. Gastroenterostomy performed well above ulcer.

Subsequent history.—Patient made an excellent recovery. Heart symptoms relieved immediately after operation. August 31, 1914, patient does his work, eats well, and suffers only occasionally from vague digestive symptoms.

Case 2. Mrs. A. O. Age, 36. Date, January 2, 1914. (Figs. 10, 11, and 11a.)

History.—Came under observation of Dr. J. R. Verbrycke on December 11, 1913. Two months before had had appendicectomy and freeing of adhesions about cecum. Has had symptoms referable to stomach for at least 12 years. Suffers from frequent attacks of vomiting and headache, which come on irregularly every few days and sometimes lasting for several days. She has sometimes remained well for several months, when attacks return. No colic or cramps. The vomiting usually occurs about one hour after eating. Markedly constipated.

Physical signs.—Right kidney palpable and slightly tender. Splash sound only over upper half of epigastrium. Slight tenderness over entire epigastrium, but one very tender spot in left nipple line 2 inches above the umbilicus. No occult blood in feces. Only 5 c. c. of stomach contents obtained. Excess of mucus. Free acid, 40. Total acidity, 50. Remnants of undigested food end of 24 hours.

Clinical diagnosis.—Constipation. Acid catarrh. Migraine. Nephroptosis. Lavage of stomach was practiced every other day until December 26. There were no symptoms while this was continued, but no improvement took place in emptying of stomach.

Roentgenological examination.—January 2, 1914. Stomach is orthotonic. A deep incisura is present on the upper third of the greater curvature, causing hourglass stomach. Directly opposite to incisura is a well-localized area of tenderness. Small six-hour residue in lower sac. The evidence points to ulcer of the lesser curvature. The hourglass condition is largely spasmodic, since the incisura is not constant in depth.

Operative findings.—January 19, 1914. Bandlike constriction of upper third of stomach. Many adhesions about anterior border of lesser curvature were separated by finger, disclosing an opening in the stomach which admitted tip of finger. Tissue surrounding ulcer congested and friable. Ulcer was excised and lower sac anastomosed with upper, almost entire width of stomach being used.

Subsequent history.—Practically no shock following operation. Cautiously fed buttermilk and other liquids for two weeks. Felt well until February 27, when she began to have some epigastric pain. Vomited several times up to March 10, when roentgenograms were again made. (Fig. 11.) Roentgenograms show hourglass contraction at same place as before operation. The contraction is mostly spasmodic, as shown by the fact that much of the bismuth remains in the upper sac for about five minutes and then suddenly nearly all of it passes into the lower. Was given atropin for considerable time. Has gained in weight and does not suffer from any digestive symptoms at present time, although she states that her stomach "does not yet feel right." Roentgenograms on August 24, 1914 (fig. 11a), show that the hourglass constriction is still present. It seems now to have more of the characteristics of an organic contraction.

Case 3. Mrs. J. R. Age, 50. Date, March 28, 1914. (Fig. 12.)

History.—Patient of Dr. J. R. Verbrycke. Has had "stomach trouble" for 13 years. Twelve years ago had severe hemorrhages from stomach and was treated in bed for six weeks. Since then has had recurrent attacks, with periods of complete freedom from symptoms. Complains principally of pain in the epigastrium a short time after eating. Burning and nausea, with occasional vomiting. All symptoms partially relieved by alkalies.

Physical examination.—Abdomen pendulous. Recti relaxed. Well localized point of tenderness left of median line, midway between ensiform and umbilicus. Gastric contents: Free acid, 60; total acid, 74. Occult blood, faint. String test, could not swallow string.

Roentgenologic examination.—March 28, 1914. Stomach orthotonic; freely movable. Well-localized tender spot about middle of lesser curvature. Large six-hour residue. Well-marked incisura on upper third of greater curvature. No examination of colon was made. The evidence points to the presence of an ulcer of the lesser curvature. Operation was advised, but refused. Two weeks later the patient was seized with severe cramplike pains in abdomen. There was general tenderness over entire abdomen; slight rigidity of both recti; temperature, 100° F.; pulse, 98; leucocytes, 5,400. Perforation of gastric ulcer suspected. During next eight hours temperature rose gradually to 101.6° F., while other signs remained the same. A second leucocyte count at this time was 3,400, and a third count, one hour later, was 2,800. Patient was then operated upon.

Operative findings.—On lesser curvature, just above middle of lesser curvature, was a markedly congested area about size of a half dollar, covered with fine, fresh adhesions. A slight thickening of the stomach walls was evident in this area. There was no perforation. No other abnormality was found in the abdomen. Gastroenterostomy was performed. Twelve hours after operation temperature was normal and leucocyte 6,600.

Post-operative history.—August 31, 1914. Patient made a good recovery from the operation, but her symptoms have improved only slightly. She suffers in much the same way that she had for years previous to the operation. Still has indigestion, nausea, burning, and some pain.

Case 4. Mrs. A. C. Age, 49. Date, November 10, 1913. (Fig. 13.)

History.—Patient of Dr. William Gerry Morgan, whom she first consulted on December 11, 1912. During previous September had infected hand, which was incised several times. States that she has had digestive disturbances for past four years, during which time she has had three attacks. The last attack has lasted for several months. Symptoms are severe pain in epigastrium, gas in stomach, poor appetite, and pyrosis. Pains begin when somach is empty and stop for short time after meals. Greatly constipated. Emaciated and pale.

Physical examination.—Chest negative. Abdomen flabby. Tender spot about middle of epigastrium. Free HCl 66. Occult blood in feces. Patient given medical treatment with alternate improvement and relapse.

Roentgenological findings.—Stomach hypertonic. Marked incisura about middle of greater curvature. Sharply localized tenderness immediately opposite to incisura on lesser curvature. Patient was very weak and unable to return for six-hour examination. Evidence points to presence of lesser curvature.

Operative findings.—Thin scar of old ulcer close to pylorus on lesser curvature. About middle of lesser curvature was a very red, hard, indurated nodule about size of a cherry—a penetrating ulcer. Gastroenterostomy was performed, although this would seem to have been an ideal case for excision.

Post-operative history.—Patient has shown little improvement in general symptoms.

Case 5. Miss D. Age, 36. Date, March 8, 1914. (Fig. 14.)

History.—Had pelvic operation in January, 1911. Gained in weight and felt well for several months, when she fell and injured coccyx, which was subsequently removed. About one year ago began to suffer from periodic epigastric pain. These pains came on from one-half to two and one-half hours after eating, but lately they have started almost immediately after eating. Is sometimes nauseated, but never vomits. Has lost considerably in weight. Is constipated.

Analysis of stomach contents has not been made.

Roentgenologic study.—Esophagus negative. Stomach is hypertonic and lies well up in epigastrium, largely to left of spine. A well-marked incisura is present on upper third of greater curvature.

Medium-sized six-hour residue. Well-localized pressure tender point opposite incisura. No constant deformity of duodenal cap. No evidence of abnormality of small intestine or colon. Diagnosis, ulcer of lesser curvature.

Operative findings.—May 10, 1914. Callous ulcer about size of penny on lesser curvature in position indicated by incisura. Ulcer excised and posterior gastroenterostomy performed. Patient made good recovery, and at this date (Aug. 25, 1914) has had no return of symptoms.

CASE 6. Miss T. Age 32. Date, January 5, 1913. (Figs. 15 and 16.)

History.—Has had recurrent attacks of indigestion since childhood. Pain in epigastrium followed by vomiting. These symptoms have grown progressively worse during the past few years. November 4, 1912, came under observation of Dr. Mallory. Pain in lower part of abdomen, which is worse after eating. Has vomited undigested food before breakfast several times.

Test breakfast.—One hundred c. c. removed. Half liquid. Total acid, 38. No blood. Occult blood in feces on meat-free diet. Einhorn string test positive.

Clinical diagnosis is gastric ulcer.

Roentgenologic examination.—January 5, 1913. Stomach orthotonic, fixed in epigastrium. No incisura. Medium six-hour residue. Constant deformity of antrum pylori. Evidence points to presence of callous ulcer, with extensive adhesions. No evidence of malignancy.

Operative findings.—January 10, 1913. Large callous ulcer, with much induration, on lesser curvature near to pylorus. Extensive adhesions present. Gastroenterostomy performed. Surgeon said induration about pylorus looked malignant.

Subsequent history.—Patient has never regained strength and has not increased in weight since operation. Roentgenologic examination on April 7, 1913 (fig. 16), shows rapid emptying of stomach through artificial opening. Several examinations made since that time show that most of the food leaves the stomach through the artificial opening and only a small amount through the pylorus. The patient has suffered from attacks much the same as before the operation; in fact, has every evidence of the continued presence of gastric ulcer.

CASE 7. Mr. J. N. S. Age, 53. Date, October 23, 1913. (Figs. 17, 17*a*, and 17*b*.)

History.—Patient came under observation of Dr. William Gerry Morgan on February 25, 1912. Duration of illness at that time, 30 months. Principal complaint is of pain in epigastrium, coming on two or three hours after eating. He thinks food remains in stomach all night. Pain sometimes relieved by drinking water. Constipated.

Physical examination.—Chest negative. Depression of epigastrium with prominence of umbilical region. Peristaltic waves plainly seen over umbilical region. In right lumbar region on bimanual palpation is felt a small, hard, freely movable mass, which may or may not be right kidney. No localized tender spots.

Gastric analysis.—Amount, 70 c. c. Free acid, 34. Total acid, 64. Trace of occult blood. Lavage in fasting state shows marked retention. Thread test positive. Was given medical treatment, dieting, etc., until October 23, 1913, without permanent improvement. On the latter date the patient had lost in weight and was very pale and weak.

Roentgenologic examination.—There is marked deformity of the bismuth shadow of the entire pyloric end of the stomach, especially of the lesser curvature. Large six-hour residue. The evidence shows that there is pyloric obstruction, probably organic in character, and points to the presence of extensive adhesions or cicatricial contraction involving the pyloric antrum. Beginning malignancy can not be ruled out.

Operative findings.—October 26, 1913. A large "saddle ulcer" just proximal to pylorus surrounded by large cicatrix. Many fine adhesions along lesser curvature. When stomach was opened for gastroenterostomy the pyloric orifice was found almost completely occluded by the contracting scar tissue. There was some induration about the ulcer, but it was the surgeon's opinion that it was not malignant. Only gastroenterostomy was performed.

Post-operative history.—Patient made a good recovery and rapidly gained in weight and strength. February 3, 1914, Roentgen examination showed complete occlusion of pylorous and food passing freely through artificial opening. (Fig. 17*b*.) Patient has remained in good health and remarkably free from symptoms.

CASE 8. Mr. P. Age, 62. Date, May 18, 1914. (Fig. 18.)

History.—One brother died of gastric cancer. Patient was injured by falling window, the corner of which struck him in epigastrium, on July 30, 1913. Gradually lost appetite, weight, and strength. Came under observation of Dr. C. S. White on May 16, 1914. States that he has had constant pain in epigastrium for past five or six weeks. No nausea or vomiting. Has lost about 28 pounds during past two months. Palpable tumor in epigastrium.

Roentgenologic examination.—Defects in bismuth shadow of pyloric end of stomach are quite typical of gastric carcinoma.

Operative findings.—May 23, 1914. Large carcinoma involving lesser curvature of stomach and adherent to liver and head of pancreas. Many enlarged glands. Entirely inoperable. Died May 31, 1914.

Case 9. Mr. G. S. C. Age, 53. Date, December 26, 1913. (Fig. 19.)

History.—Came under observation of Dr. William Earl Clark on December 24, 1913. Patient states that he has been well all his life. Had operation for hernia 11 years ago. During past month has suffered from loss of appetite and generally "run-down" feeling. Has lost 10 pounds in past month. Says that he felt perfectly well until one month ago. His wife states, however, that he has had no appetite and has suffered from loss of weight and strength for at least three months. He now complains of feeling of heaviness and discomfort in stomach. Always feels badly after meals until he can vomit. Bowels quite regular.

Physical examination.—Skin pale, hard, and dry. Chest negative. Liver not enlarged. Abdomen shows a protuberance in upper left epigastrium about size of an orange. No tenderness over it. Percussion over it is tympanitic, and over it is the only place where the splash sound can be elicited. A small, hard mass can be felt in the pyloric region.

Gastric analysis shows much mucus, no free HCl, a small amount of lactic acid, and occult blood. Lavage before breakfast shows large residue with blood.

Roentgenologic findings.—December 26, 1913. Bismuth passes through esophagus more slowly than usual, and there is slight delay at the cardiac end. Shadow of the entire pyloric end of stomach is replaced by long, thin line of bismuth. Marked deformity of cap. The appearance is that of a large carcinoma involving much of the pyloric end of the stomach and producing obstruction, which causes dilation of the cardiac end. Inoperable.

Operative findings.—Operation January 7, by Dr. John Wellington. Considerable amount of free fluid in peritoneal cavity. Large carcinomatous mass involving pylorus and pyloric end of stomach. No attempt at removal. Carcinomatous nodules in peritoneum and omentum. A loop of jejunum was fixed in wound, through which patient was fed. Died, after several attacks of hematemesis, on January 13, 1914.

Case 10. Mrs. Wm. H. Age, 53. Date, April 27, 1913. (Fig. 20.)

History.—Case of Dr. Thomas Claytor, who first saw her on April 18, 1913. Patient complains of indigestion, with belching immediately after eating. No abdominal pain nor discomfort. Says she has lost somewhat in weight. First noticed abdominal discomfort in January, 1913. Has not vomited. April 20, 1913, vomited a large amount. On the latter date a small movable mass was felt in the right iliac region, pressure upon it causing pain, which radiates to the back. Patient feels well in the morning, but by evening abdomen is much distended.

Roentgenologic examination.—Stomach greatly enlarged. Required 72 hours for complete evacuation. Entire absence of cap. Indentations at pylorus suggesting carcinoma. The evidence points to obstruction at the pylorus, probably carcinoma, and very likely operable.

Operative findings.—Patient delayed operation until June 15. Hard ring-shaped carcinoma at pyloric end of stomach. Did not involve liver, and there seemed to be little involvement of any of the surrounding tissues. The patient died from shock a few hours after the operation.

Case 11. J. R. (colored). Age, 49. Date, December 22, 1913. (Fig. 21.)

History.—Only history obtainable is that the patient has been gradually losing weight and strength for about seven months. Has no pain, but vomits whenever he eats. Palpable tumor in epigastrium.

Roentgenologic examination.—Stomach much enlarged due to pyloric obstruction. Defects in the bismuth shadow point to presence of tumor (probably carcinoma), involving region of pylorus, much of lesser curvature and area of greater curvature just below pylorus.

Operative findings.—Carcinomatous mass about size of fist, involving pylorus and lesser curvature nearly to cardia. Nodules on under surface of liver. Enlargement of glands. Abnormal appearance in Roentgenogram below pylorus was caused by several adhesions in that region.

Patient died one week after operation.

Case 12. Mr. J. V. C. Age, 66. Date, March 18, 1914. (Fig. 22.)

History.—Felt perfectly well until last June, when he began to be constipated and to have occasional sharp pains through abdomen, accompanied by belching. Gradually began to have a feeling of stoppage of food when he swallowed. In August went to physician, who gave him some charcoal tablets, which he took during entire winter. Has lost 22 pounds in weight since last June. Came under observation of Dr. Camp Stanley on March 16, 1914. States that he consulted doctor at this time only upon solicitation of friends, since he is suffering no pain or inconvenience which would make it seem necessary to him to consult doctor. Has at the present time no other discomfort than slight feeling of stoppage of food when he eats and slight soreness in the epigastrium.

Physical examination.—Definite feeling of tumor in epigastrium. No tenderness to pressure.

Roentgenologic examination.—Stomach very small and fixed high in epigastrium. Bismuth meal passes through pylorus almost as rapidly as it enters stomach. The evidence points to an extensive infiltrating carcinoma.

Patient rapidly became weaker, and died six weeks after above examination, never having suffered any pain nor shown any evidence of pyloric obstruction. No autopsy was permitted, but it is thought that the diagnosis of gastric carcinoma is reasonably certain.

Case 13. Mr. S. S. Age, 42. Date, October 18, 1913. (Figs. 23 and 23a, b, and c.)

History.—Case of Dr. William Gerry Morgan, whom he first consulted on October 17, 1913. Patient states that he has always been well until about two months ago, when he noticed some digestive disturbance—feeling of fullness after eating and belching of gas. Has lost considerably in weight and feels generally weak. Denies venereal infection of any kind.

Physical examination.—Patient is emaciated and cachectic. Indefinite feeling of mass lower part of epigastrium. Wassermann made at this time was negative. Stomach findings are not at hand, but Dr. Morgan stated that they were such as would be found in advanced carcinoma.

Roentgenological examination and course.—Stomach occupies fixed position below and to left of umbilicus. (Fig. 23.) Ragged deformity in bismuth shadow along lesser curvature near pylorus. Constant "cut-out" area along lower part of greater curvature appears in all positions and remains same in extent and shape under manipulation before screen. No cap demonstrable. Large six-hour residue. These findings point to extensive infiltrating growth of walls of stomach, probably carcinoma. Colon normal, except for some dilatation of cecum.

October 23, 1913.—Dr. Morgan states that he considers the case too far advanced for operation.

December 29, 1913.—Roentgenologic examination shows further encroachment upon gastric lumen. (Fig. 23a.) Patient has continued to lose in weight; is very weak.

February 7, 1914.—Patient has gained 12 pounds in weight in past month and states that he feels some better. Wassermann on this date is double plus. Roentgenogram shows same appearance as that taken on December 29, 1913.

February 11.—Intravenous injection of salvarsan.

March 1.—Roentgenogram shows remarkable change in appearance of stomach. (Fig. 23b.) The defect on the lesser curvature has almost entirely disappeared; the "cut-out" appearance still persists on greater curvature. Patient has increased a few pounds in weight and feels much better.

March 14, 1914.—Has had another dose of salvarsan. Roentgenographic appearance of stomach is about same as on March 1.

May 21, 1914.—Last dose of salvarsan, about three weeks ago, set up a violent diarrhea, which persisted for about two weeks. Patient improving in weight and strength. Roentgenogram (Fig. 23c) taken on this date shows some defect in the stomach shadow again, indicating recurrence of the growth.

Remarks.—The patient was lost sight of after May 21, 1914. It is thought that a comparison of the roentgenologic findings on different dates and the course of the case under treatment with salvarsan makes the diagnosis of gumma of the stomach reasonably certain. For mention of other cases see Progressive Medicine, December, 1912.

Case 14. Mrs. R. Age, 42. Date, February 4, 1913. (Fig. 24.)

History.—Patient of Dr. William J. Mallory. Was operated on in 1907 for pelvic condition. During past seven or eight years has had attacks of indigestion, at first months of good health intervening, but now attacks are more frequent. Attack comes on four or more hours after eating. The attack begins with very severe pain in middle of epigastrium, always radiating toward left side. The pain is relieved only by morphine. Vomiting sometimes occurs or is induced, but does not give relief. Attacks are uninfluenced by nature of diet. Stomach contents show no blood.

Roentgenologic examination.—Stomach orthotonic and shows no evidence of any abnormality. Small intestine and colon negative. All plates show a small shadow, which is believed to be that of a gallstone.

Operative findings.—Operation by Dr. William C. Borden, February 5, 1913. One small stone, oval in shape, removed from common duct.

Subsequent history.—Good recovery, and has remained well to present time, August 25, 1914.

Case 15. Mr. V. D. Age, 62. Date, May 11, 1914. (Fig. 25.)

History.—Came under observation of Dr. William Mallory on April 30, 1914. Family history without significance. No excesses, except that he has worked excessively and has eaten large amounts of coarse food. In 1911 had an attack of "acute indigestion," from which he recovered within a few days. In 1912, after hard work, much worry, and eating only boiled vegetables, suffered considerable abdominal discomfort and lost weight. After treatment and diet he regained lost weight and felt well. The same condition recurred in summer of 1913 and has persisted to present time. He now finds that certain foods, such as tomatoes and oranges, cause burning and eructations, relieved by soda. Cold water causes nausea and vomiting. The condition is giving him more and more trouble. His stomach seems to become full before his appetite is satisfied. Often has to leave table and vomit. Has slight choking sensation when he swallows. Weight three years ago was 165; in 1913 was 155; April 30, 1914, is 135.

Physical examination.—Test breakfast showed total acid 30, free HCl 8, combined HCl 14. Occult blood in gastric contents. Fourteen hours after eating 30 c. c. yellow fluid obtained containing pus, blood, and epithelium.

Under medical treatment felt better, but continued to lose in weight. May 13 weight was 131½.

Roentgenoligic findings.—Esophagus negative; food passes into stomach without unusual delay or deviation. Stomach is very small and empties with unusual rapidity. No peristaltic waves are visible. There is no incisura and no defect in the bismuth shadow to suggest either ulcer or carcinoma. The small stomach emptying very rapidly suggests infiltration of stomach walls, possibly "linitis plastica."

Operative findings.—May 18, 1914. Both walls of stomach were free but whole of lesser curvature and all of anterior surface seems to be converted into scar tissue. The walls are greatly thickened. A wedge-shaped piece down to the mucosa was removed for examination. Nothing further was done.

Microscopic findings.—Large amount of connective tissue and evidence of inflammation. Nothing to suggest malignancy.

Postoperative history.—Made good recovery from operation. Sufferers from same symptoms as before. September 3, 1914, weighs 127½ pounds.

Remarks.—It is reasonably certain that this is a case of cirrhosis of the stomach (linitis plastica). It seems to be the general opinion that there is a true cirrhosis of the stomach characterized by the presence of much connective tissue and the products of every stage of inflammation and producing great thickening of the stomach walls. Many cases have been described, however, with the general appearance of this condition, but in which, after prolonged search, carcinomatous changes were found. It is quite possible that examinations of other areas in this case would show such changes.

Case 16. Mr. W. C. L. Age, 40. Date, February 14, 1913. (Fig. 26 and 26a.)

History.—Came under observation of Dr. William Gerry Morgan on January 6, 1911. Acute inflammatory rheumatism when 18 or 19 years of age. Acute attack of appendicitis when 25. Double hernia soon after this. Attack of acute abdominal pain eight years ago variously diagnosed as gallstone colic, obstruction of the bowels, and appendicitis. Three years ago had appendix removed and operations on both sides for radical cure of hernia. The operations gave no relief to symptoms from which he was suffering. He complains especially of constipation and of pain in left side of upper abdomen about 4 every afternoon. Nausea and vomiting when pain is severe. Pyrosis when stomach is empty.

Physical examination.—Chest negative. Belly scaphoid. Double hernia scars. Decided tenderness over descending colon and sigmoid. Splashing sound from ensiform and mid epigastrium. Free HCl. 40. Total acid, 52. No blood in stomach contents. Occult blood in feces. Urine shows nothing abnormal.

Roentgenologic examination.—Stomach orthotonic. No incisura. No six-hour residue. Marked, constant deformity of duodenal cap. No ileal statis. No evidence of abnormality of the colon. Shadow on right side believed to be that of calculus in right kidney. Evidence points to adhesions about duodenal cap.

Operative findings.—March 1, 1913. Extensive adhesions, involving pyloric end of stomach and duodenal cap. Gall bladder not involved. A few adhesions also found between descending colon and sigmoid. The adhesions were freed about the stomach and colon and nothing else attempted.

Postoperative history.—For about six months the patient remained entirely free from symptoms, ate well, and gained in weight. At the end of that time symptoms began gradually to recur, and on April 19, 1914, he was again losing in weight and suffering as much as before. Roentgenologic examination at that time showed again evidence of very extensive adhesions about the duodenal cap.

Patient had stone removed from pelvis of right kidney early in May. Made good recovery. Has gained in weight and now (Sept. 30) feels quite well except for slight pains in right side.

CASE 17. Mr. T. D. Age, 46. Date, January 10, 1914. (Fig. 27.)

History.—Consulted Dr. William Gerry Morgan on January 10, 1914. Has never had any acute illness. Is nauseated all the time. Much constipated and suffers all the time from indefinite feeling of general abdominal discomfort. Lack of strength and hebetude.

Physical examination.—Moderate tenderness along entire course of colon. Clinical diagnosis is chronic colitis and constipation. Lavage and other medical treatment failed to relieve.

Roentgenological examination.—Small hypertonic stomach high in epigastrium. Small six-hour residue. No incisura. No filling defects. No deformity of cap. Ileal stasis and filling defect in terminal portion of ileum. Cecum is higher than usual and markedly fixed in position. The evidence points to presence of adhesions about cecum and terminal ileum.

Operative findings.—Operation on February 10, 1914, by Dr. George Tully Vaughan. Presence of a typical Lane's kink demonstrated. Membrane causing it was severed. Appendix quite normal, but was removed.

Postoperative history.—Patient seen on August 10, 1914. Has remained perfectly well to present time. Constipation relieved; is not nauseated and suffers no discomfort whatever.

Case 18. Mr. R. B. Age, 61. Date, May 28, 1914. (Fig. 28.)

History.—Patient of Dr. Gerry Morgan, who first saw him on May 29, 1914. The patient says he has suffered from stomach trouble for the past 30 years. His greatest trouble is from chronic constipation. Tries every means to keep bowels open. Enemas ineffective. He is very restless at night, sleeping little after 1 a. m. He complains particularly of a grumbling pain and sense of fullness in the right iliac region.

Physical examination.—Habitus enteroptoticus. Chest negative. Abdomen flat and soft. No rigidity of recti. No tenderness in right iliac region nor in any other part of abdomen. Free HCl, 40. Total acid, 56. No occult blood in stomach or feces.

Roentgenologic findings.—Atonic stomach, considerably larger than usual. Greater curvature at brim of true pelvis when patient is erect. No incisura or defects of filling. Large six-hour residue. Marked ileal stasis and defects of filling of the last inch of the ileum. The evidence points to the presence of a typical Lane's kink, causing obstruction at the ileo-cecal junction.

This case has not been operated. The roentgen findings are very positive, and it is thought that his symptoms are adequately explained by the diagnosis of ileac stasis.

Case 19. J. P. B. Age, 34. Date, February 1, 1914. (Fig. 30.)

History.—Patient of Dr. William Gerry Morgan. First seen on January 21, 1914. Every few weeks has attack of severe pyrosis, usually worse during night, amounting to pain, which compels him to get up and walk about. Vomiting does not relieve. Pain is worse a short time after meals and is confined to epigastrium. Feels "run down" and has no strength or ambition.

Physical examination.—Chest negative. Abdomen practically negative except for slight tenderness over lower half of epigastrium. Free HCl, 44. Total acid, 58. Occult blood found in stomach contents.

Roentgenologic findings.—Stomach hypertonic. No incisura; no six-hour residue. Entire stomach lies unusually far to right. The cap is small and deformed. No ileac stasis. The cecum is greatly dilated. There is definite fixation at the hepatic flexure. The evidence points to the presence of adhesions about the duodenal cap, probably involving the gall bladder and to the presence of adhesions or Jackson's membrane about the hepatic flexure.

Operative findings.—Operation by Dr. J. D'Arcy Magee on February 16, 1914. Cholecystitis, with adhesions involving first part of duodenum. Extensive Jackson's membrane about hepatic flexure and first part of transverse colon, causing a sharp kink. Adhesions were freed and appendix, which was unusually long but not otherwise abnormal, removed.

Post-operative history.—Made good recovery and has had no recurrence of any abdominal symptoms. (Oct. 1, 1914.)

Case 20. Mrs. C. Age, 52. Date, February 3, 1914. (Figs. 31 and 31a.)

History.—Seventeen years ago right tube and ovary were removed. Has had attacks of indigestion for eight years. Recently they have been frequent and severe. The attack comes on with severe pain through upper part of abdomen, which becomes greatly distended with gas. Never vomits. Obstinate constipation for years. Diagnosis of both gallstones and gastric ulcer have been made by different physicians. Physical examination shows some enlargement of left ovary, but it is freely movable and not tender to pressure. Urine shows no abnormality. No localized tenderness at any point over abdomen. Diagnosis can not be arrived at by clinical means.

Roentgenological examination.—February 2, 1914. Stomach shows no evidence of abnormality. No ileal stasis. Great dilatation of cecum and hepatic flexure. Marked kink a few inches distal to hepatic flexure. First part of transverse colon adherent to ascending colon and cecum.

Operative findings.—Operation on February 9, 1914, by Dr. Lawson. Thick membranous band attached to transverse colon about 4 inches distal to hepatic flexure, stretching tightly across front of ascending colon to be attached to parietes external to ascending colon. This band produced a sharp kink, causing partial obstruction of transverse colon. Another smaller band extended from a point on the transverse colon to the lower end of the cecum. These bands were divided and the colon was plicated by sewing two of the longitudinal bands together from the cecum to the hepatic flexure. Left ovary enlarged. Was not removed.

Subsequent history.—Good recovery. Patient has had no attacks of pain since the operation, and is not constipated. She has remained well to this date, August 25, 1914.

Case 21. Mrs. A. C. Age, 45. Date, November 4, 1913. (Figs. 32 and 32a.)

History.—Came under observation of Dr. William Gerry Morgan on May 2, 1912. Twelve years ago had operation for "womb trouble." Says she was worse after operation, and was again operated three years later for same trouble. This relieved her. For several years she has suffered from very obstinate constipation. Gas formation after eating, with excessive belching. Appetite good when bowels are open. Suffers from pain over entire abdomen, especially when constipated. Pain has no relation to eating.

Physical examination.—Abdominal examination is negative. Free HCl, 48; total acid, 68. No blood in stomach contents or feces. Patient was given treatment over considerable periods of lavage of colon, albolene, etc., without improvement.

Roentgenological findings.—Stomach orthotonic. No incisura. No filling defect. No 6-hour residue except small amount in cap. End of six hours practically all of bismuth meal is in ileum. End of 24 hours cecum is well filled and head of column is at splenic flexure, but there is only a small amount beyond hepatic flexure. Considerable bismuth in ileum end of 24 hours. Roentgenogram after enema shows cecum fixed in position on a level with iliac crest. The lower end is bent inward at a right angle. This evidence points to the presence of extensive adhesions about terminal ileum and cecum, and also about hepatic flexure. The residue in the duodenal cap and the low position of the second portion of the duodenum suggest that the duodenum may also be involved in the adhesions about the hepatic flexure.

Operative findings.—Operation on November 25, 1914, by Dr. L. H. Reichelderfer. Very extensive adhesions involving cecum, hepatic flexure, terminal ileum, and also duodenum and gall bladder. Adhesions caused angulation of lower end of cecum. The adhesions were thoroughly freed.

Post-operative history.—January 4, 1914. Patient made good recovery from operation. Still has some abdominal pain. Roentgenogram shows that there is still some fixation of the transverse colon at same point as before operation.

August 25, 1914.—Patient has regained health almost completely. Still somewhat constipated, but suffers practically no pain.

CASE 22. Mr. V. G. A. Age, 38. Date, March 13, 1914. (Fig. 33.)

History.—Patient of Dr. J. R. Verbrycke, whom he consulted on February 22, 1914. Family history unimportant. No other illness except rheumatism three years ago. Says he has had stomach trouble recurrently for years. Complains principally of gas collecting and pressing upon heart. Dizziness and headache. Pyrosis when stomach is empty. Obstinate constipation. Has occasional dull pains in region of appendix.

Physical examination.—Well-built man. Right rectus decidedly more tense than left. Well-localized tenderness over McBurney's point only. Considerable meteorism. Urine normal. Stool normal except for occult blood, but patient says his gums bleed. Thirty c. c. of stomach contents obtained; normal appearance; occult blood faint; free HCl, 50; total acid, 70. Hemoglobin, 74 per cent. White count, 5,900.

Roentgenologic findings.—Stomach is orthotonic and shows no filling defects. No incisura. Very slight six-hour residue. No deformity of cap.

The ileum shows a marked narrowing at the ileo-cecal junction and some residue at end of 24 hours. Cecum movable, but adherent in whole extent to transverse colon, the proximal part of the latter extending vertically downward to lowermost part of cecum. Evidence points to presence of extensive adhesions, involving terminal ileum, cecum, and transverse colon.

Operative findings.—Operation on March 16 by Dr. H. H. Kerr. Retrocecal appendix bound down by adhesions. Extensive Jackson's membrane, involving cecum, ascending colon, and first part of transverse colon. When this membrane was freed the colon could be seen to unfold.

Post-operative history.—The patient still suffers somewhat from constipation, but it is not so bad as before operation. All other symptoms have disappeared.

CASE 23. Mrs. H. L. Age, 33. Date, November 24, 1913. (Fig. 34.)

History.—Came under observation of Dr. William Gerry Morgan on September 22, 1913. History of recurrent attacks of epigastric pain for the past 17 or 18 years. The pain always begins from one-half to one hour after eating and is sometimes accompanied by vomiting.

Physical examination.—Some slight tenderness over entire course of colon; very tender in right iliac region. Liver and spleen just palpable. Free HCl, 34. Total acid, 52. No blood in stomach contents. Occult blood found in feces on meat-free diet.

The clinical evidence points to the presence of gastric ulcer and appendicitis.

Roentgenologic findings.—Stomach hypotonic. No incisura. No deformity of cap. No six-hour residue. No ileac stasis. The cecum is smaller than usual and is fixed in a position somewhat higher than common. There are constant defects in the filling of the cecum, which, taken with its fixation and contracted condition, point to the presence of extensive adhesions.

Operative findings.—Operation on December 2, 1913, by Dr. H. H. Kerr. There is no evidence of abnormality of the stomach. The cecum is fixed high in right iliac region and is small. A strong, tense band is attached to one of the linea about 3 inches above the origin of the the appendix and extends upward and inward to be attached to the omentum. At this same level on the cecum are many adhesions, which extend entirely around it. The cecum at this point is red and thickened, evidently due to a chronic inflammation. The appendix appears entirely normal, but was removed. A few fine cobweb adhesions about the hepatic flexure were freed.

Post-operative findings.—The patient made a rapid recovery and has remained entirely free from any abdominal symptoms.

Remarks.—This case illustrates the well-known fact that symptoms referable only to the stomach are often caused by lesions elsewhere in the abdomen. It also emphasizes the fact that localized colitis is not confined to the immediate region of the appendix and is not uncommon at other points in the colon. The value of the roentgenologic examination is shown by the accurate localization of the cause of the stomach symptons, which must have been reflex.

Case 24. Mr. R. S. G. Age, 36. Date, May 12, 1914. (Fig. 35, 35a, and 35b.)

History.—Patient of Dr. Paul Johnson.

1907: "Stomach trouble" and lost flesh. Improved under treatment.

1908: Seminal vesiculitis. Rectal massage with cure. A short recurrence later.

1911: Business strain, followed by insomnia. Became steadily worse, until very bad in November. Complexion became very dark down to clavicles. Slowly improved while being treated by an osteopath.

1912: Great mental fatigue shortened day's work. Stopped work April 1. In May appetite was good and there was no constipation. Thought power much retarded. Marked insomnia. Sleep disturbed by unpleasant dreams.

Physical examination at that time showed deep tenderness over region of appendix. In July had two attacks on successive nights—the first, nausea and vomiting, without pain; second, general abdominal pain, with distention. Was seen by Dr. Johnson two weeks later, when examination showed mass in right iliac fossa. Temperature, 100.4. Operated July 30, 1912, by Dr. George Tully Vaughan. Appendix vessels prominent, otherwise normal. Fine membrane over ascending colon and first part of transverse colon. Mass felt was probably dilated cecum. Appendix was removed and adhesions freed.

January, 1913: Patient has suffered from about same symptoms since operation as before. Is now obstinately constipated. Has much distention from gas. Deep pressure over cecum causes great pain. Stool shows considerable mucus. "Rheumatism" in knees and back. Does not sleep well except when bowels are thoroughly open.

The condition remained about the same until May 12, 1914, when roentgenologic examination was made.

Roentgenologic findings.—Stomach hypotonic. No incisura. No filling defects. No six-hour residue. No deformity of cap. Bismuth remaining in ileum end of 24 hours. Head of bismuth column then at hepatic flexure. End of 48 hours most of the bismuth is still in the cecum and hepatic flexure. Colon filled with enema shows dilatation of cecum and hepatic flexure. Fixation of proximal part of transverse colon to descending colon and cecum. The evidence points to the presence of extensive adhesions, involving cecum, hepatic flexure, and terminal ileum.

Operative findings.—May 22, 1914. Operation by Dr. C. S. White. Dilation of cecum and hepatic flexure. Very extensive adhesions, causing fixation of proximal part of transverse colon to cecum. Terminal ileum also involved in adhesions. Adhesions were freed.

Post-operative history.—September 3, 1914. Patient made good recovery and his general condition is much improved. He is still somewhat constipated, but is improving. Fluoroscopic examination of colon on this date shows no evidence of fixation about cecum or hepatic flexure.

Case 25. Mr. E. C. Age, 17. Date, January 3, 1914. (Fig. 37.)

History.—Came under observation of Dr. Gerry Morgan on October 14, 1911. Complains principally of constipation. Never has a natural movement. For past year has had much bloating. Has headache and dizziness much of the time. Feels weak all the time. Passes much gas with bad odor. No appetite.

Physical examination.—Abdomen scaphoid. No rigidity or resistance. No tender spots. Free acid, 64. Total acid, 92. No blood in stomach contents or stool. Was given general treatment for constipation and kept under observation until January 3, 1914, without improvement.

Roentgenologic findings.—January 3, 1914. Stomach findings negative. No evidence of ileac stasis. Cecum greatly enlarged and freely movable. Marked reduplication and fixation of the folds about the hepatic flexure. The reduplicated folds are movable en masse, but can not be separated from each other. The evidence points to cecal and colonic stasis due to ahhesions and reduplication about the hepatic flexure.

Operative findings.—Operation January 7, 1914. Reduplication at hepatic flexure caused by extensive, thick membrane, probably inflammatory in origin, and connected with the omentum. Adhesions were freed.

Post-operative history.—Recovered promptly and has remained well. Daily stools without laxative. Good appetite. He has remained free to present time, August 26, 1914, from all symptoms from which he suffered before operation.

Case 26. Miss C. Age, 35. Date, March 10, 1914. (Figs. 38, 38a, and 38b.)

History.—Underwent operation several years ago for pelvic trouble; does not know exact nature. Since that time she has been obstinately constipated, and has constant feeling of discomfort, sometimes amounting to pain, in lower abdomen.

Physical examination.—Entirely negative, except for localized tender area immediately above symphysis pelvis.

Roentgenologic examination.—No evidence of abnormality of stomach. No ileac stasis. Cecum somewhat enlarged and freely movable. Transverse colon fixed at about its middle at a point low in the pelvis. Fixation could not be determined by palpation in front of the fluoroscopic screen, because the lowest curve of the transverse colon was not accessible to manipulation. The fact that the transverse colon remained in practically the same position when the patient was in a high Trendelenburg position as when she was horizontal, gave good evidence of fixation.

Operative findings.—The middle part of the transverse colon was adherent to the sigmoid flexure by numerous strong adhesions. No other abnormality could be found. The adhesions were freed.

Post-operative history.—Patient made a good recovery and has shown considerable improvement from former symptoms, but is still somewhat constipated.

CASE 27. B. J. Age, 3 years. Date, November 25, 1913. (Fig. 40.)

History.—Case of Dr. A. G. P. Garnett. Mother states that the child was said to have swallowed a brass rivet during the latter part of September, 1913, but the only authority she had was the statement of an older child who had been playing with the patient. She had noticed about that time some difficulty in breathing. About the middle of October the child developed a painful swelling of the glands of the neck and at the same time a rotation of the head to the right. The child was then examined by several physicians, including a throat specialist. An X-ray examination was also made, but evidently only of the chest, for nothing was found. The swelling in the neck gradually subsided, and one day, about November 1, the patient was swallowing a piece of bread when it clutched at its throat and cried out. Immediately afterwards it could again turn its head to the front. Child continued to lose in flesh, still had difficulty in breathing, and would swallow only liquids. Was treated by the local physician for worms. Consulted Dr. Garnett on November 24.

Roentgenological examination.—November 25. Shadow of rivet in upper part of esophagus, with base in lumen and bar embedded in posterior wall; not in breath passages as suspected.

Operative findings.—Dr. Charles Richardson. Under anesthetic the base of rivet could be felt with tip of finger. Base grasped with curved forceps and readily removed. Bar of rivet was bright while base was green. Small amount of pus wiped out. Child made good recovery and is now in perfect health.

Case 25. Miss B. S. Age, 9 years. Date, November 9, 1913. (Figs. 44a to g.)

History.—Case of Maj. Raymond Metcalfe, Medical Corps, United States Army. While skating to school on this date patient fell and was unable to walk afterwards. Pain in left thigh. No crepitus and only slight increase in mobility. Previous history negative, except for an infected vaccination five years ago, which left large scar on inner side of left thigh about junction of middle and lower thirds.

Roentgenologic findings and course.—Roentgenograms made on the day of injury showed an ablique fracture of the femur about the junction of the middle and lower thirds, directly through a rarefied oval area in the bone. (Fig. 44.) Roentgenograms were made at intervals while the leg was kept immobilized for healing of the fracture. On December 9, 1913, the condition was as shown in figure 44a, a lateral view, in which the cyst is well shown and the line of fracture plainly visible toward the anterior aspect. Figure 44b is an antero-posterior view taken the same day. February 9, 1914, no line of fracture could be seen; the condition on that date is shown by figure 44c. By comparing the appearance of the diseased bone with the normal one it can be seen that there was considerable thickening of the shaft above and below the cyst. (A small area can be seen where the cortex is destroyed.) A diagnosis was then made of osteitis fibrosa cystica by Dr. Leary at the Walter Reed General Hospital.

Operative findings.—March 22, 1914. Operation was performed by Dr. Bloodgood, who had the case under observation for about a month. The following is Dr. Bloodgood's description of the operation and pathological findings:

> *Operative pathology.*—After exposing the femur it was impossible to find the cyst by palpation; there was no expansion, and no thinness of the cortical bone which would allow parchment crepitation. In the periosteum on the medial or inner side only there was a point where it was adherent, and here I found a small opening, like a cloaca, which admitted a probe. I then chiseled the cortical bone and explored an area. The fat tissue of the marrow showed relations to red growths. The tissue had little white and yellow areas in it resembling giant cell sarcoma tissue and osteo-fibrosa. This tissue in places was separated by new bone formation. The healthy marrow above and below was held by new bone formation. I was able to remove this tissue with a chisel and currett, and explored the healthy marrow above and below, and leaving what appeared to be new cortical bone. I treated the disease, therefore, with the diagnosis of a giant cell tumor, but the entire gross appearance suggested a healing bone cyst. The cavity was about the size of an adult's thumb.

Dr. Bloodgood stated in a letter to Maj. Metcalfe that the microscopical examination showed "evidences of a healing process and some giant cells."

Roentgenograms made on April 21, 1914, about one month after the operation (Fig. 44d), show the cortex reformed and bridges of bone across the cavity. On July 28, 1914 (Figs. 44e and 44f), there is no evidence of cavity, but some depression on the anterior surface. On August 28, 1914 (Figs. 44g and 44h), the lesion has practically disappeared.

Remarks.—The diagnosis of this case as a benign cyst, with the characteristics of osteitis fibrosa cystica, is established by the pathological findings and the complete healing of the lesion.

CASE 29. Mr. B. S. Age, 23. Date, March 31, 1914. (Figs. 45 and 45a.)

History.—Patient of Dr. George Tully Vaughan. Three years ago had acute appendicitis, with abscess, which was drained and from which he made a good recovery. A few months later had an abscess just above elbow which necessitated currettage of bone. Remained in perfect health until one year ago, when he began to have swelling above left ankle, accompanied by dull ache. This has continued to present time. Left ankle is now three-fourths inch greater in circumference than right. Patient has kept up an active life, but always has pain in left leg.

Roentgenologic examination.—Small oval rarefied area about 1 inch above lower articular surface of tibia, one-half inch from inner surface and same distance from posterior surface. Some increased density of entire end of bone, probably due to congestion. Probably localized abscess (Brodie's abscess).

Operative findings.—Operation by Dr. Vaughan on April 1, 1914. Localized abscess in location shown by roentgenograms. It was necessary to chisel through perfectly healthy appearing bone to reach it. Streptococcus infection. Patient made rapid recovery, and has had no pain or other symptoms since.

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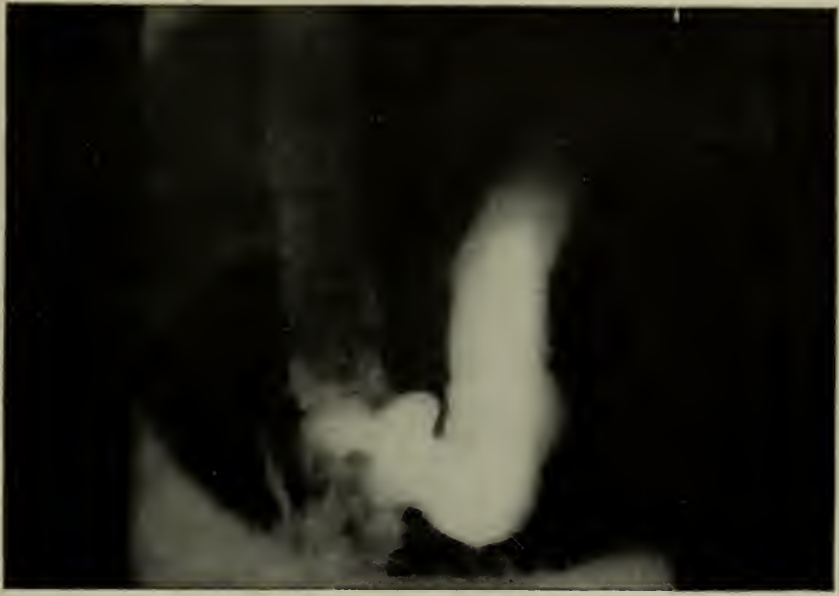

FIG. 1.—ORTHOTONIC STOMACH.

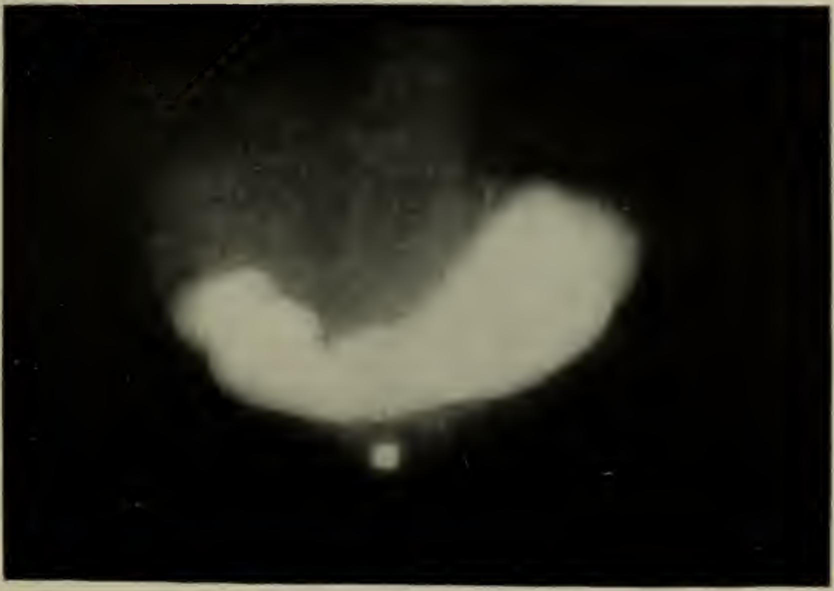

FIG. 2.—HYPERTONIC STOMACH.

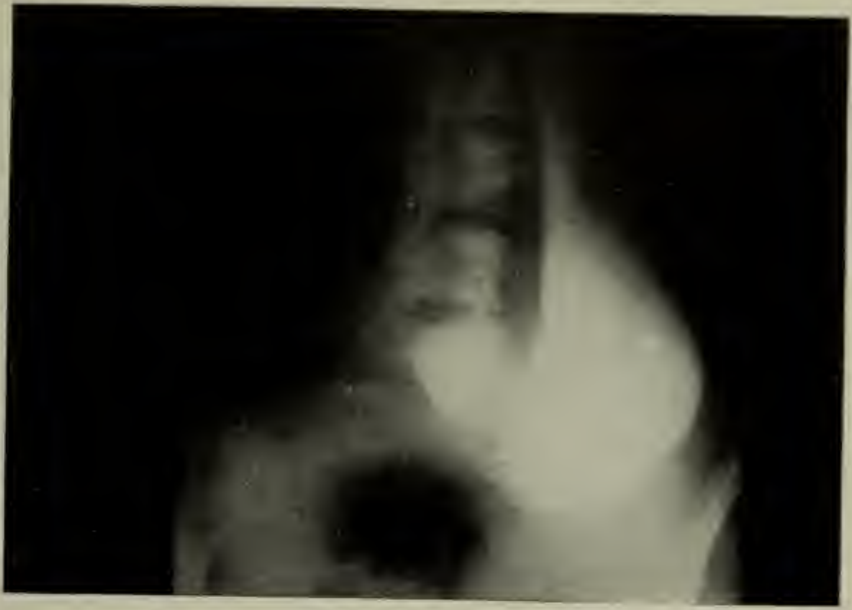

FIG. 3.—HYPOTONIC STOMACH.

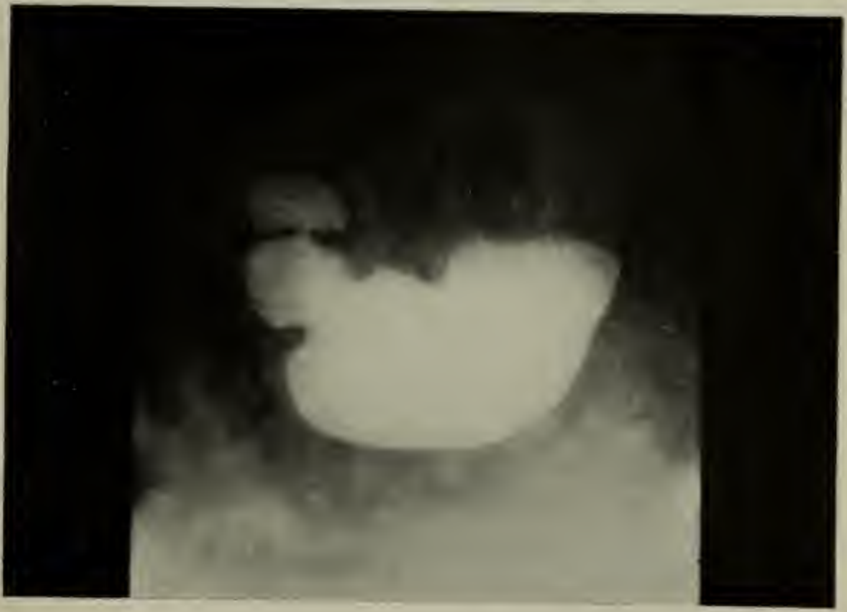

FIG. 4.—ATONIC STOMACH.

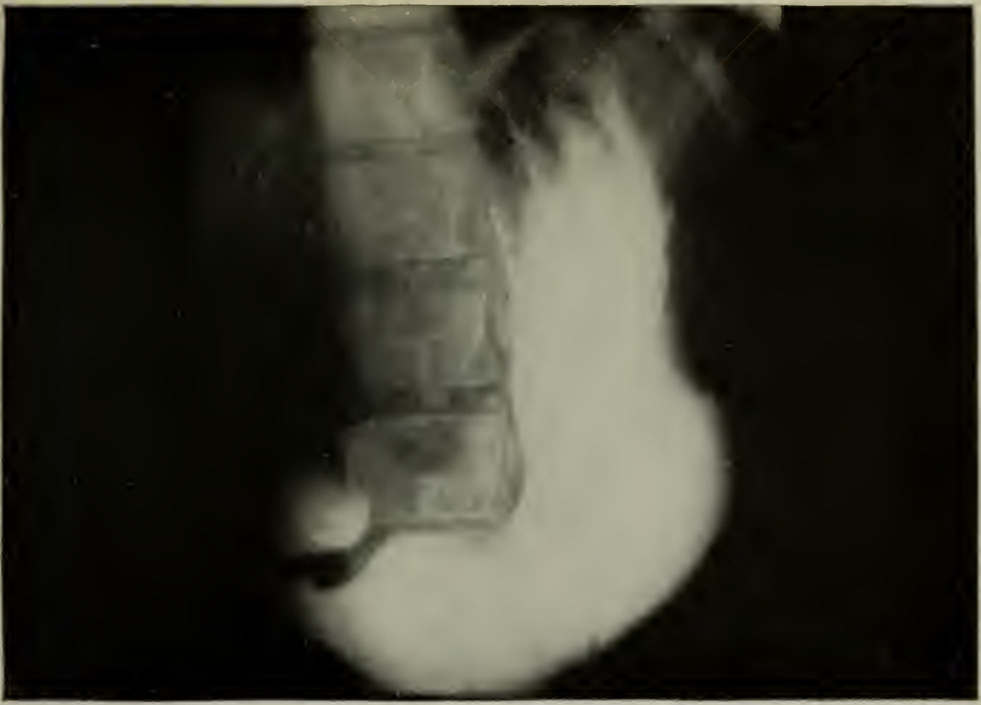

FIG. 5.—TYPE OF NORMAL STOMACH AND CAP.

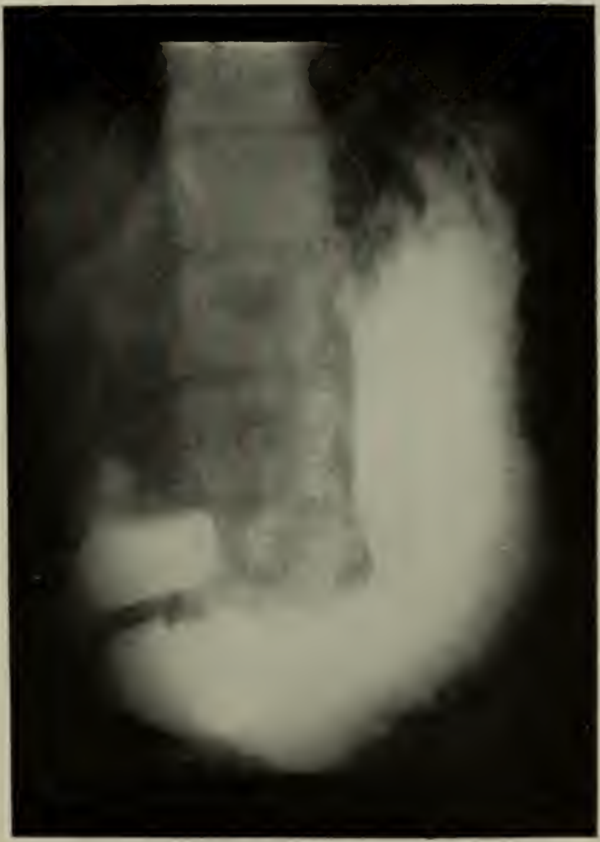

FIG. 6.—TYPE OF NORMAL STOMACH AND CAP.

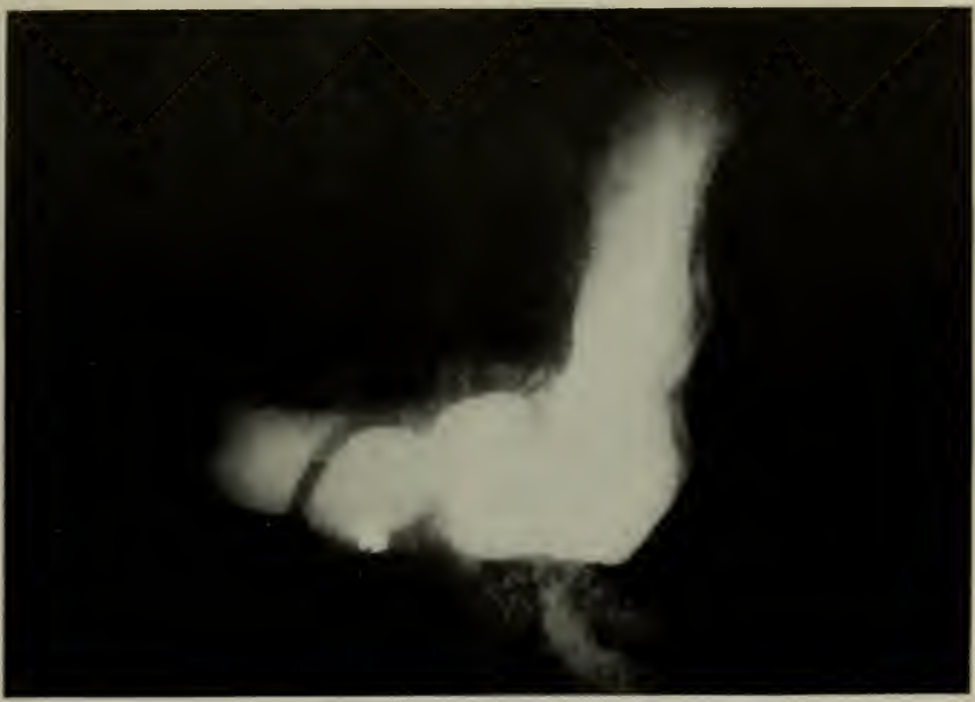

FIG. 7.—TYPE OF NORMAL STOMACH AND CAP.

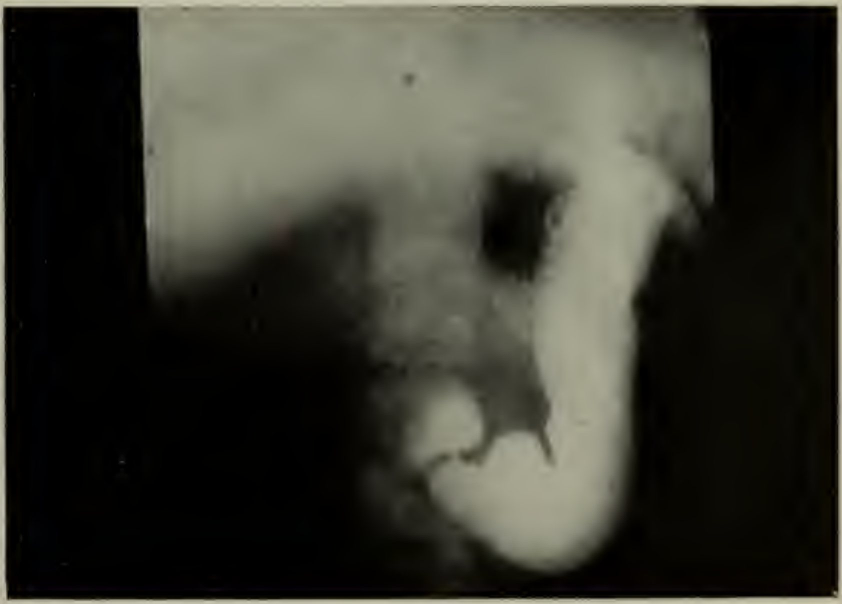

FIG. 8.—TYPE OF NORMAL STOMACH AND CAP.

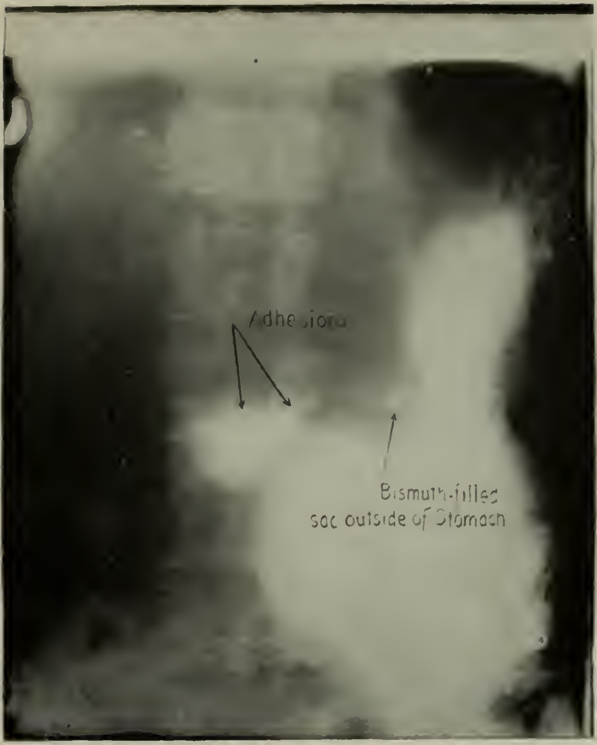

FIG. 9.—CASE 1. PERFORATED GASTRIC ULCER.

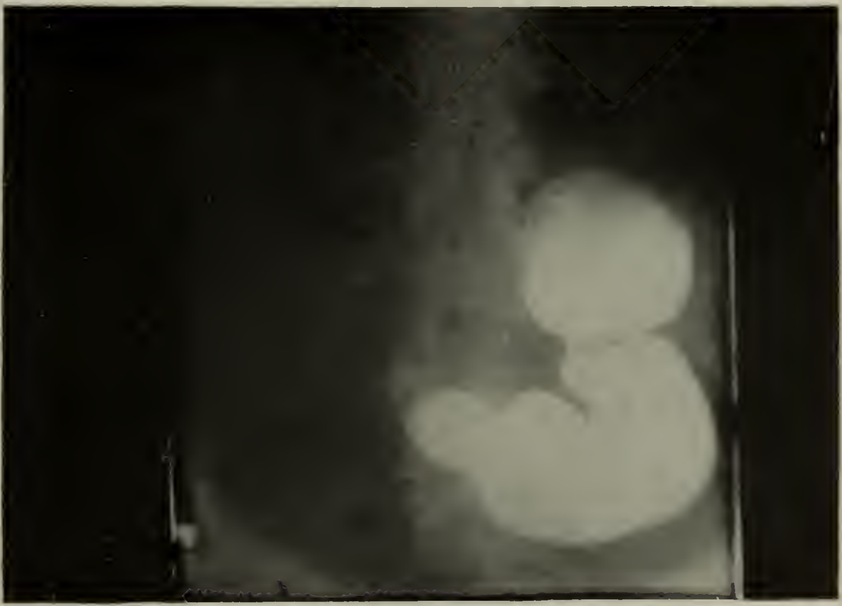

FIG. 10.—CASE 2. DEEP INCISURA PRODUCING HOURGLASS STOMACH; CAUSED BY ULCER OF LESSER CURVATURE.

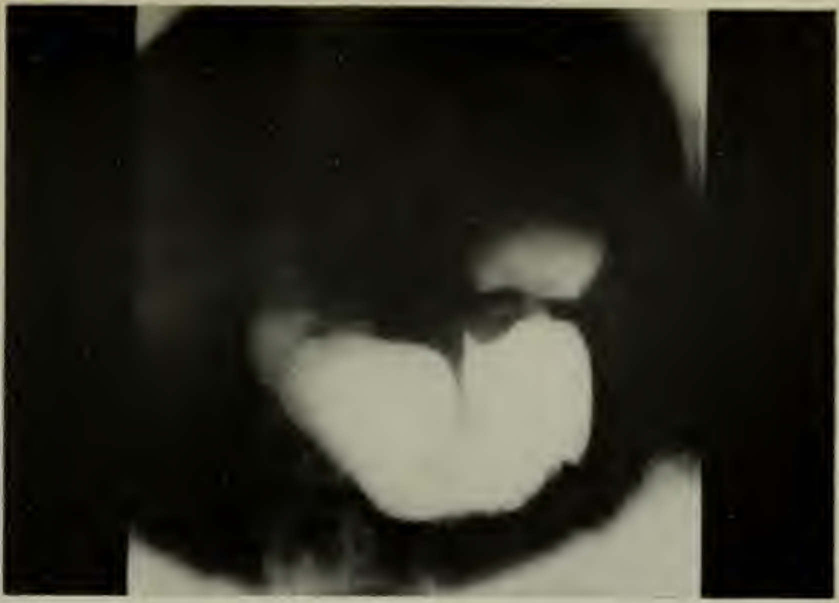

FIG. 11.—CASE 2. SEVEN WEEKS AFTER OPERATION. HOURGLASS CONTRACTION IS MOSTLY SPASMODIC.

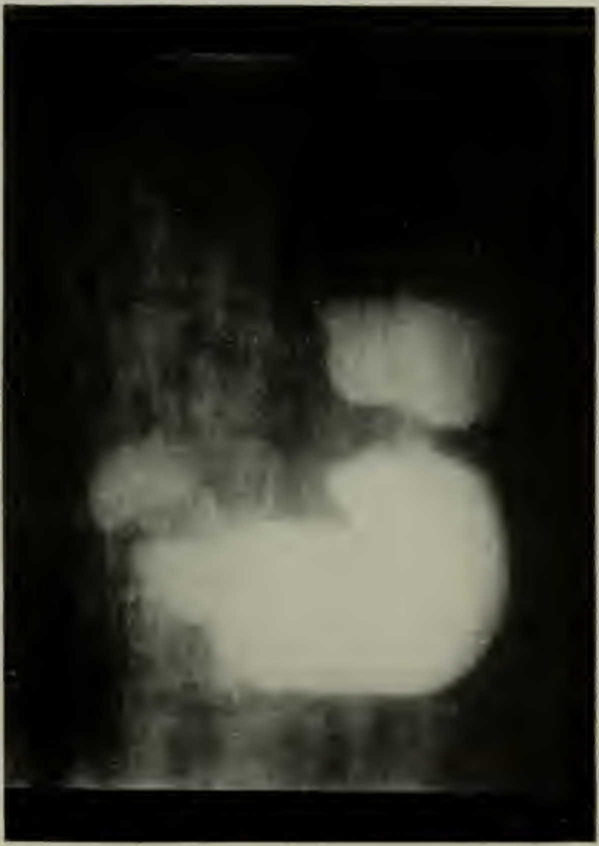

FIG. 11a.—CASE 2. SIX MONTHS AFTER OPERATION. HOURGLASS CONDITION PERSISTS.

The contraction on the side of the lesser curvature is now largely organic.

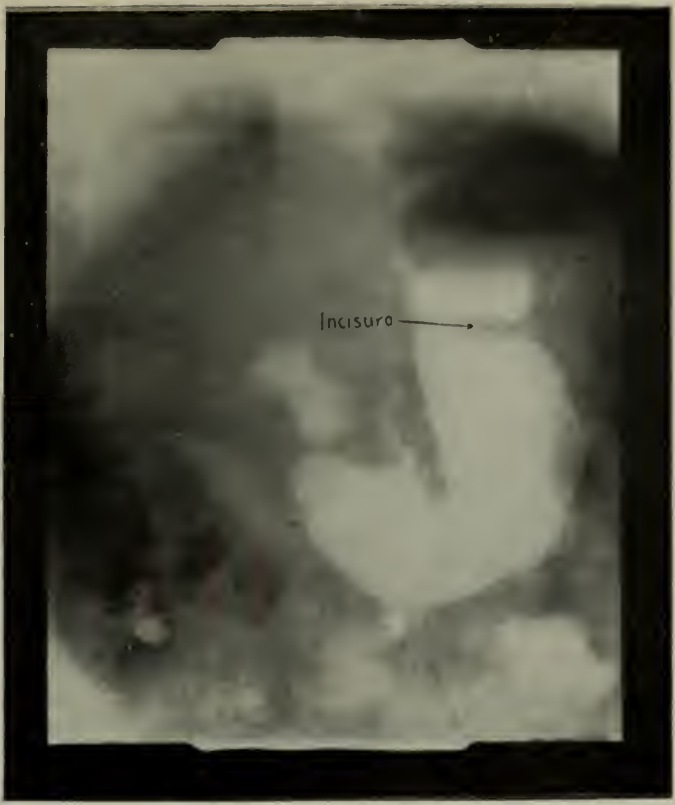

FIG. 12.—CASE 3. INCISURA OPPOSITE ULCER OF LESSER CURVATURE.

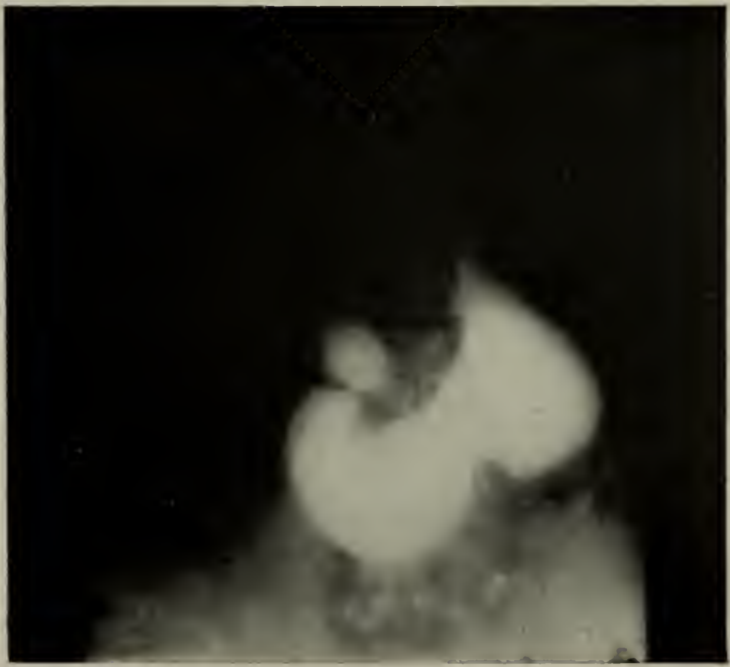

FIG. 13.—CASE 4. INCISURA OPPOSITE ULCER OF LESSER CURVATURE.

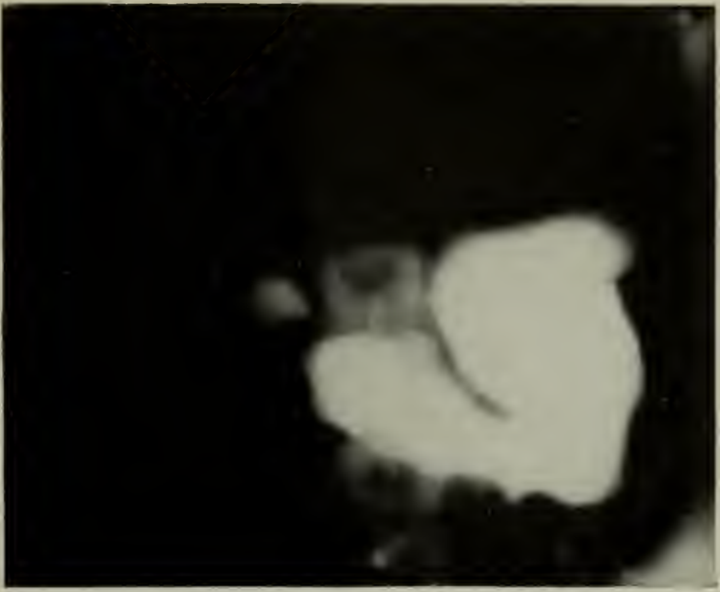

FIG. 14.—CASE 5. INCISURA OPPOSITE ULCER OF LESSER CURVATURE.

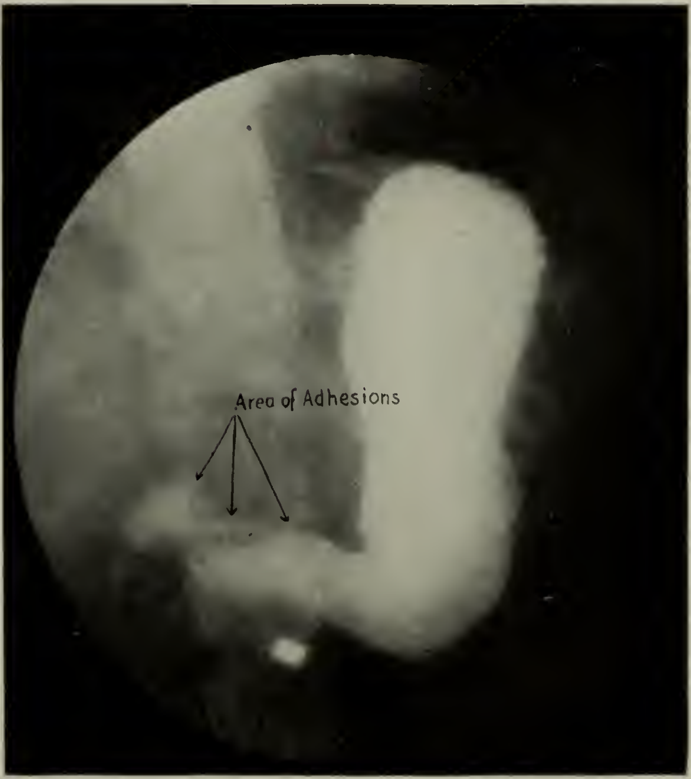

FIG. 15.—CASE 6. DEFORMITY OF STOMACH DUE TO ADHESIONS RESULTING FROM GASTRIC ULCER.

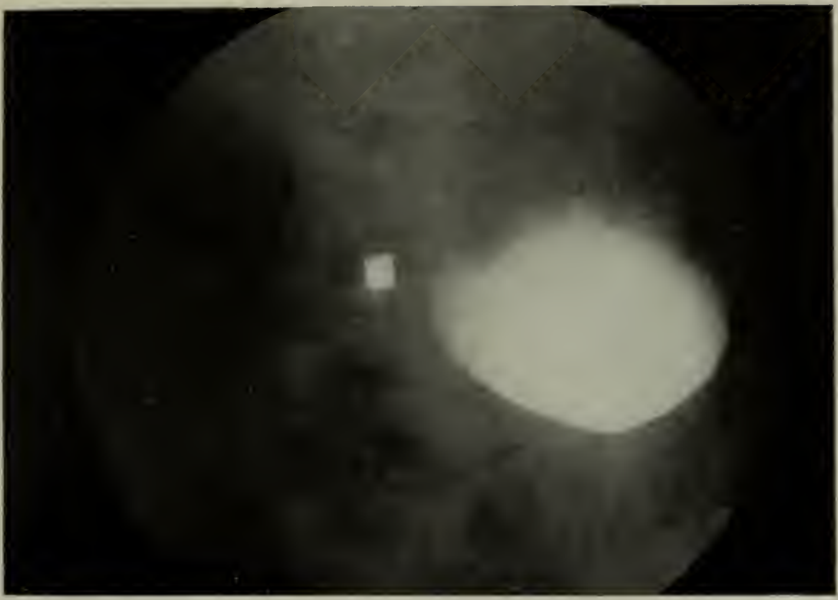

FIG. 17a.—CASE 7. SIX-HOUR RESIDUE.

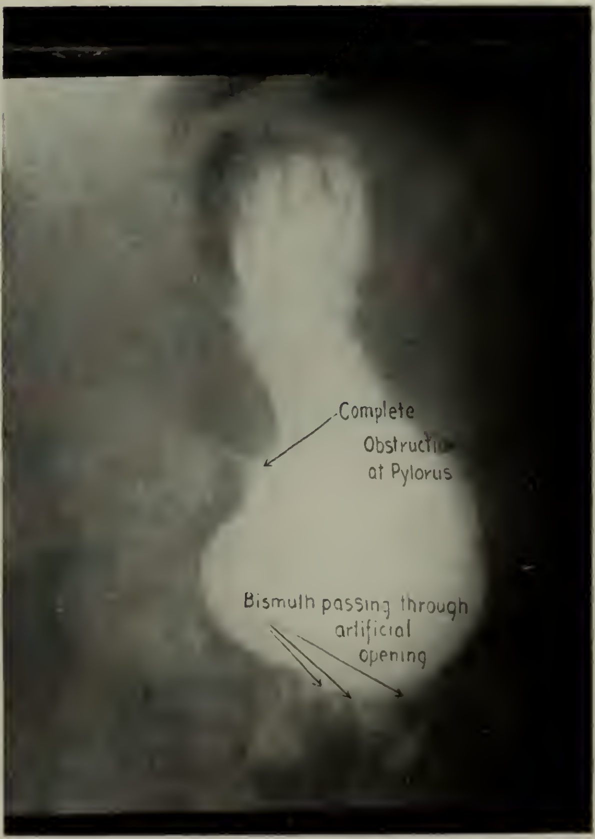
Complete Obstructi at Pylorus
Bismuth passing through artificial opening

FIG. 17b.—CASE 8. AFTER OPERATION.

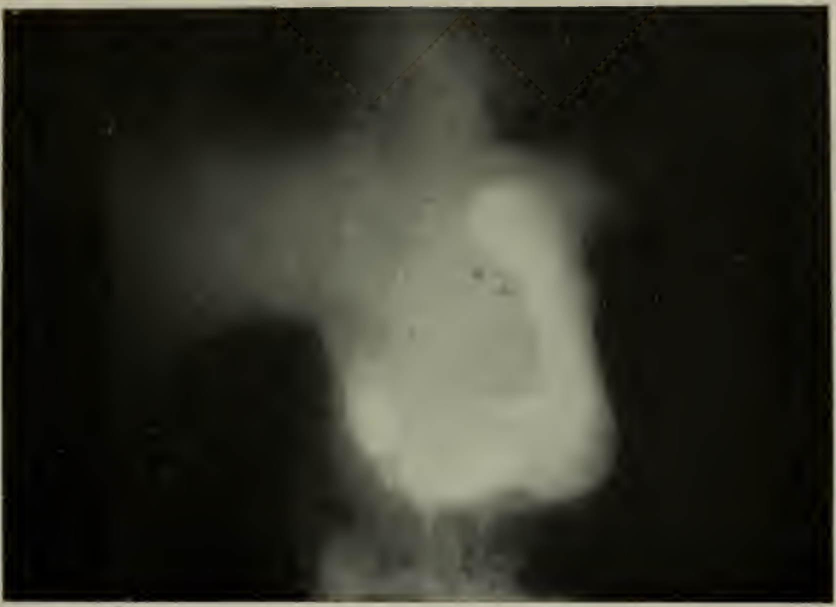

FIG. 18.—CASE 8. CARCINOMA OF THE STOMACH INVOLVING LESSER CURVATURE. NOTE THE DARK CIRCULAR AREAS LIKE "FINGER PRINTS," CAUSED BY THE IRREGULAR ENCROACHMENT OF THE TUMOR UPON THE GASTRIC LUMEN.

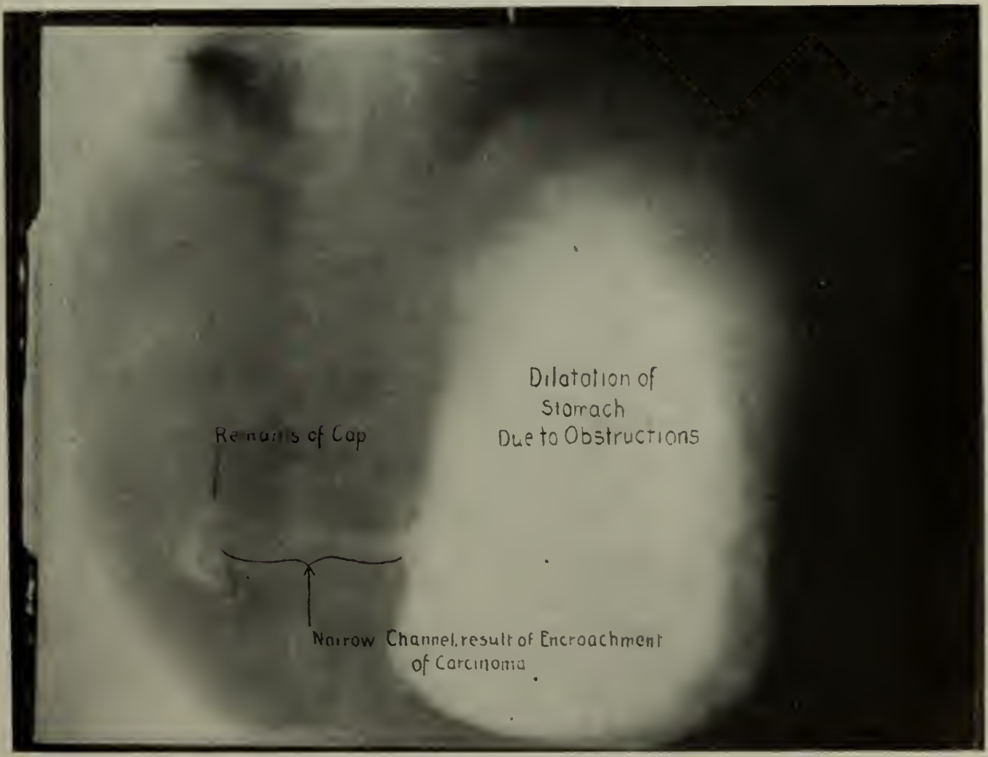

FIG. 19.—CASE 9. LARGE CARCINOMA OF PYLORIC END OF STOMACH.

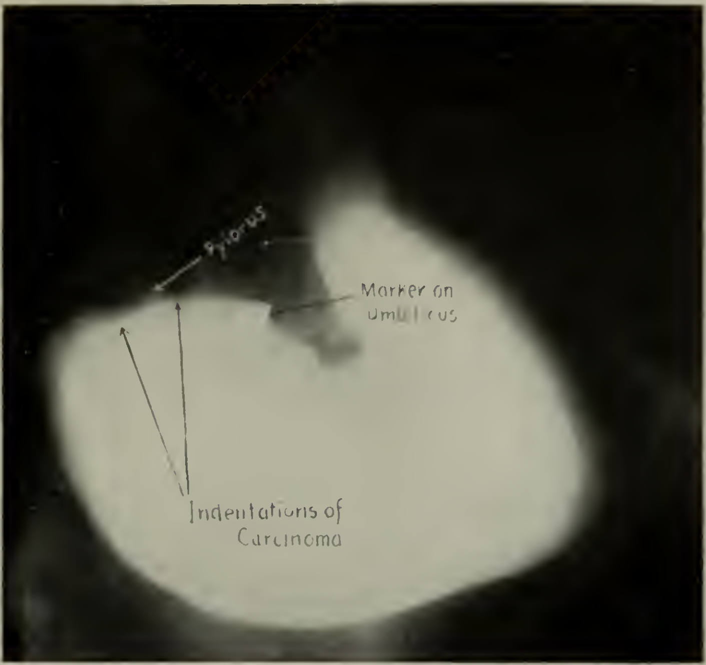

FIG. 20.—CASE 10. ANNULAR CARCINOMA AT PYLORUS.

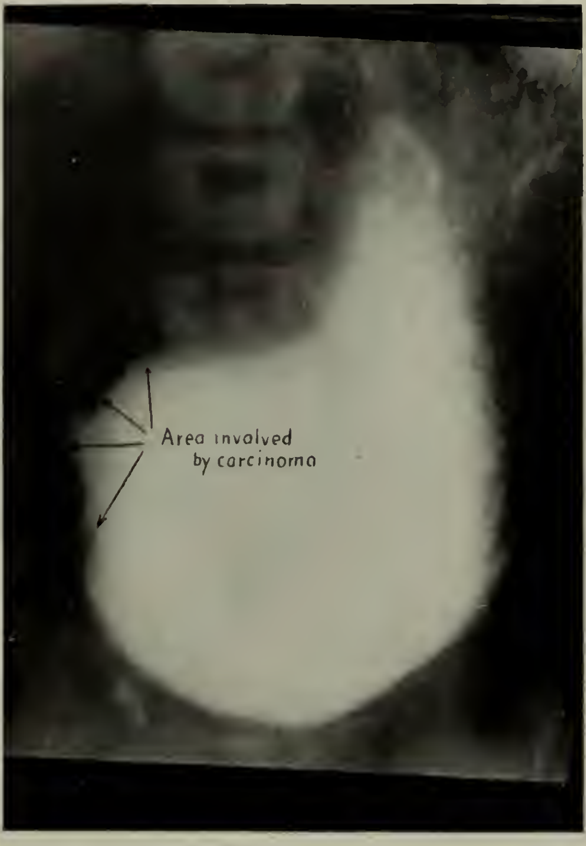

FIG. 21.—CASE 11. LARGE CARCINOMA AT PYLORUS.

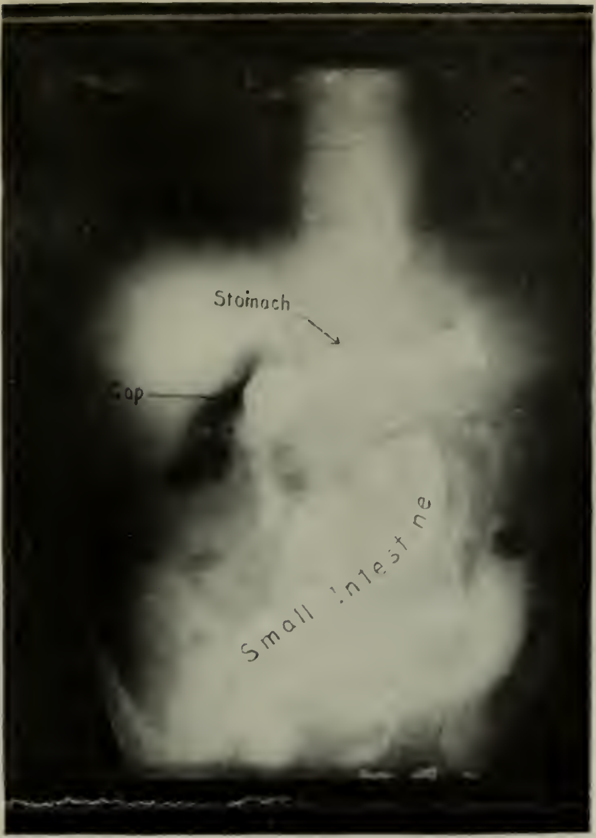

FIG. 22.—CASE 12. LARGE INFILTRATING CARCINOMA OF STOMACH. COILS OF SMALL INTESTINE FILLED WITH BISMUTH SHOWS THE EXCEEDINGLY RAPID EMPTYING OF STOMACH.

This picture was taken within two minutes after ingestion of the bismuth meal.

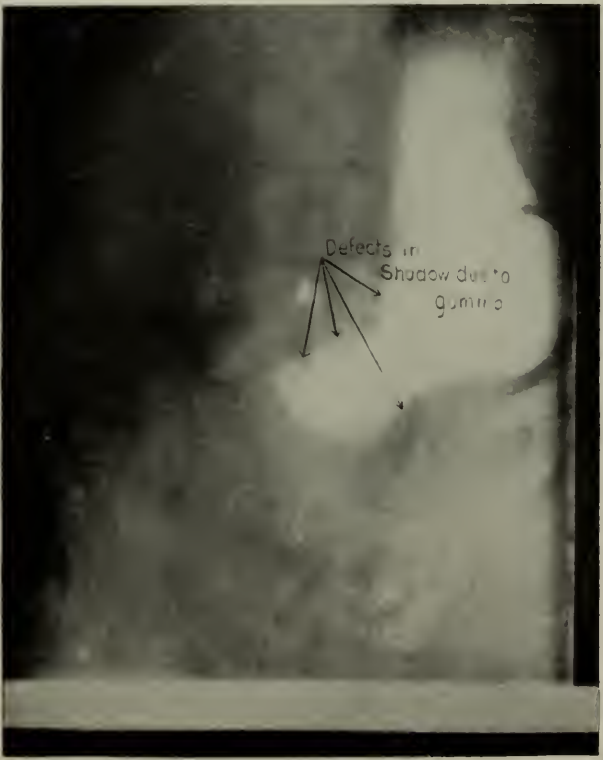

FIG. 23.—CASE 13. OCTOBER 18, 1913. GUMMA OF STOMACH.

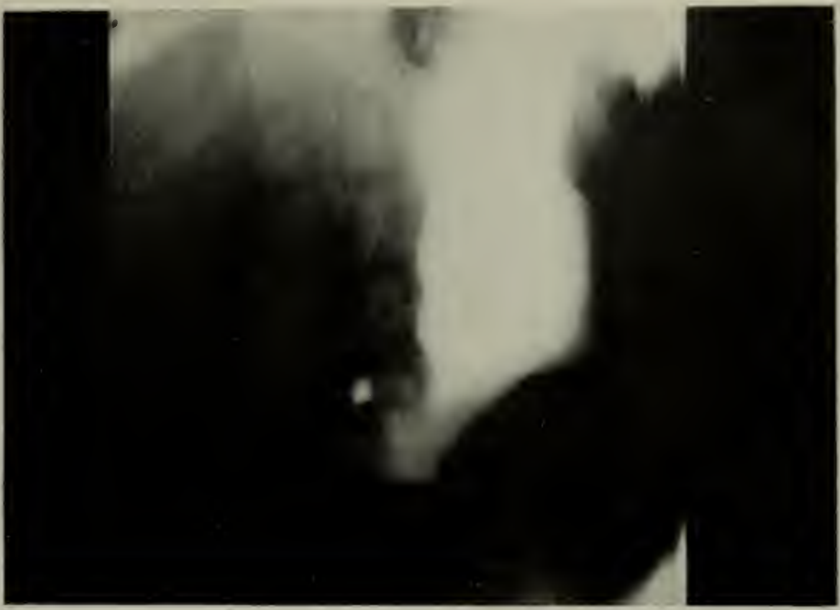

FIG. 23a.—CASE 13. DECEMBER 29, 1913. SHOWING INCREASING ENCROACHMENT UPON LUMEN OF STOMACH.

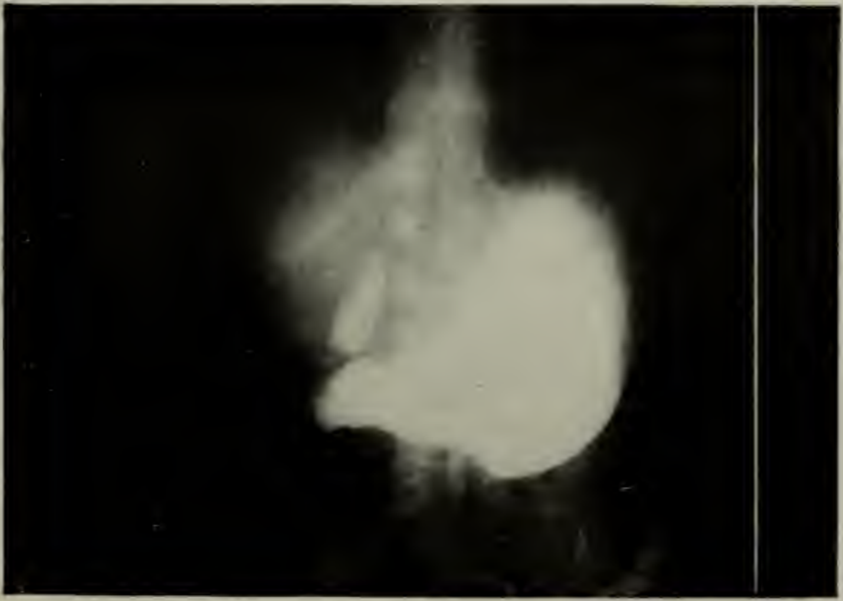

FIG. 23b.—CASE 13. MARCH 1, 1914. AFTER TREATMENT BY SALVARSAN.

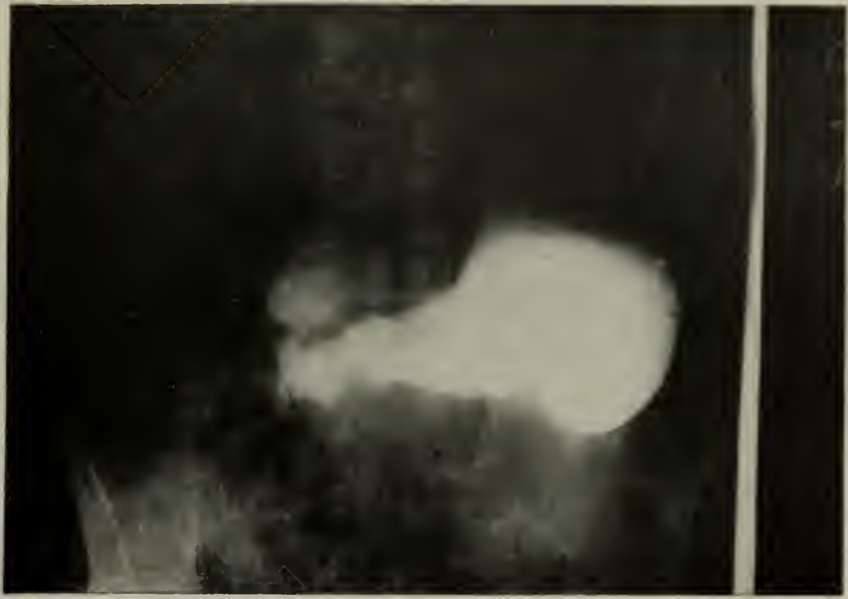

FIG. 23c.—CASE 13. MAY 21, 1914. SHOWS INDICATIONS OF RECURRENCE OF GROWTH.

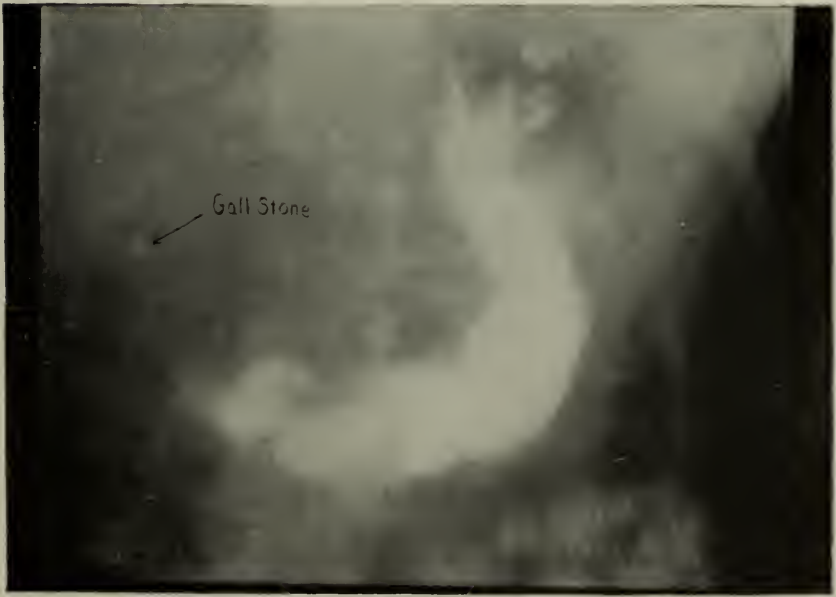

FIG. 24.—CASE 14. SINGLE GALLSTONE IN COMMON DUCT.

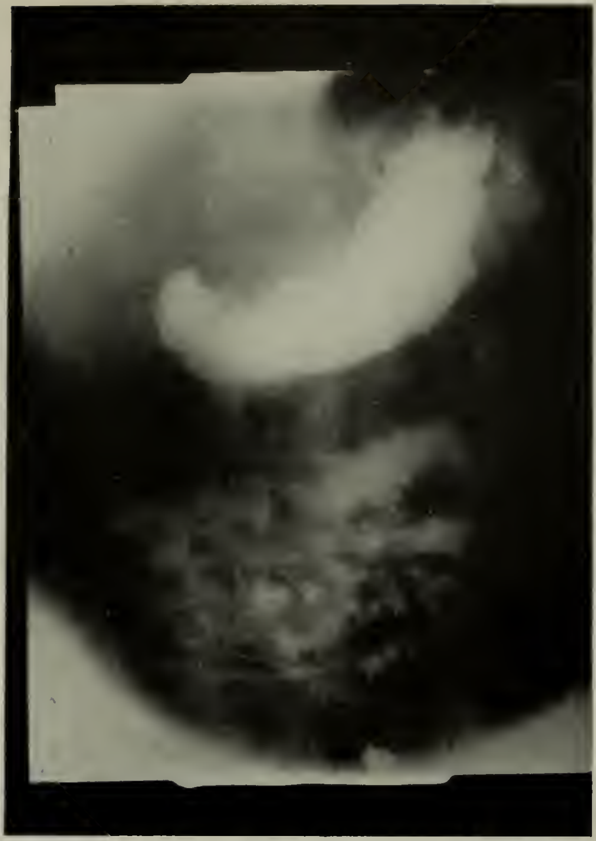

FIG. 25.—CASE 15. SMALL STOMACH OF LINITIS PLASTICA.

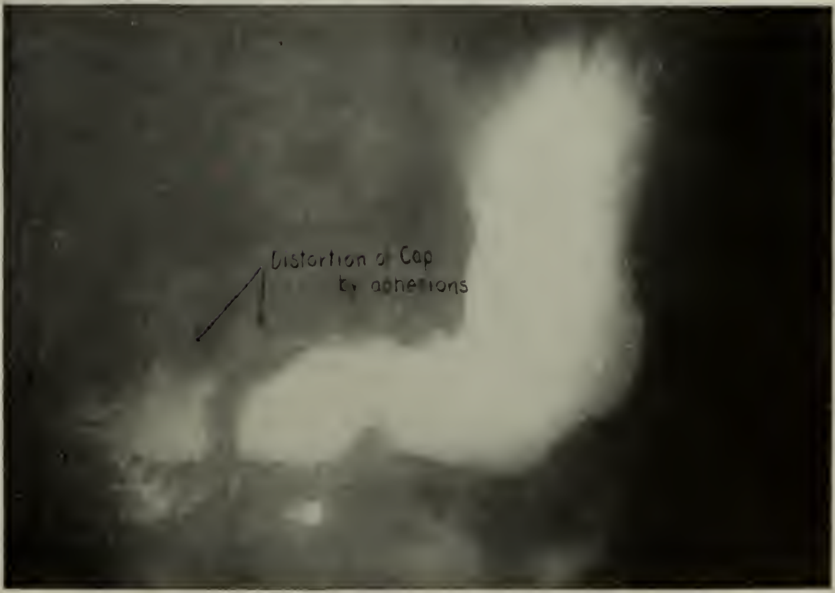

FIG. 26.—CASE 16. DISTORTION OF CAP CAUSED BY ADHESIONS.

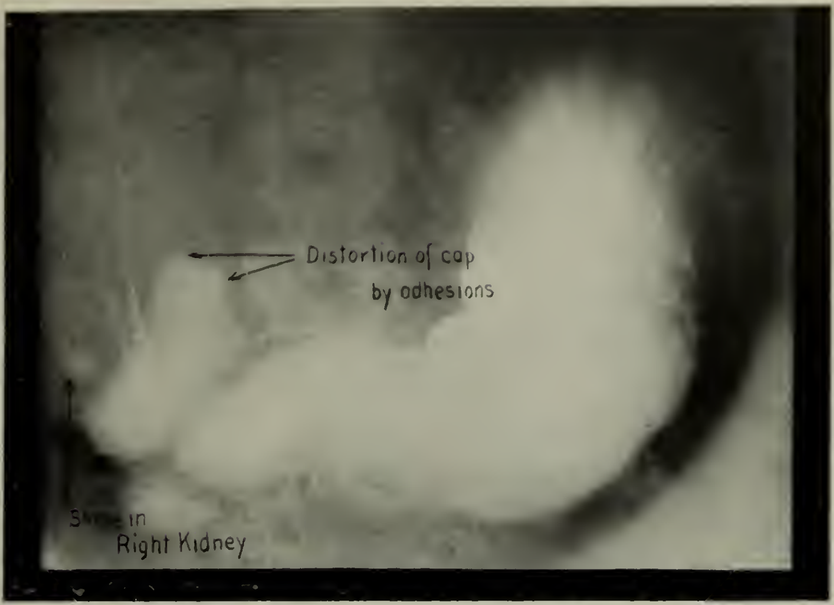

FIG. 26a.—CASE 16. AFTER OPERATION.

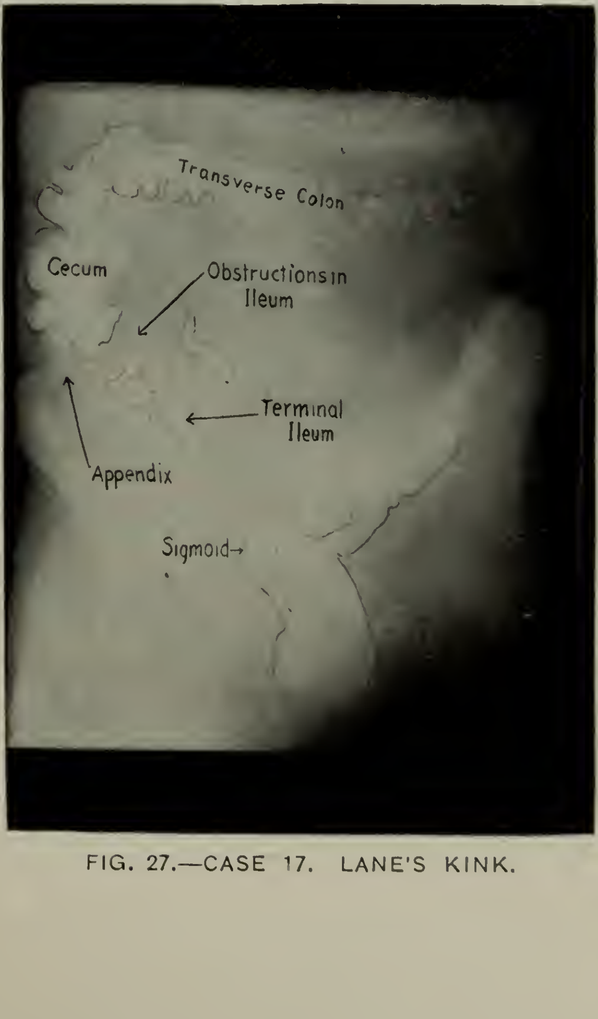

FIG. 27.—CASE 17. LANE'S KINK.

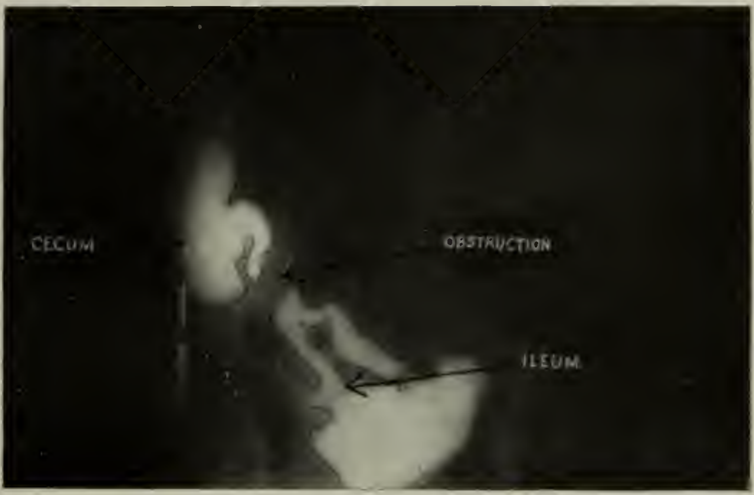

FIG. 28.—CASE 18. OBSTRUCTION IN TERMINAL ILEUM.

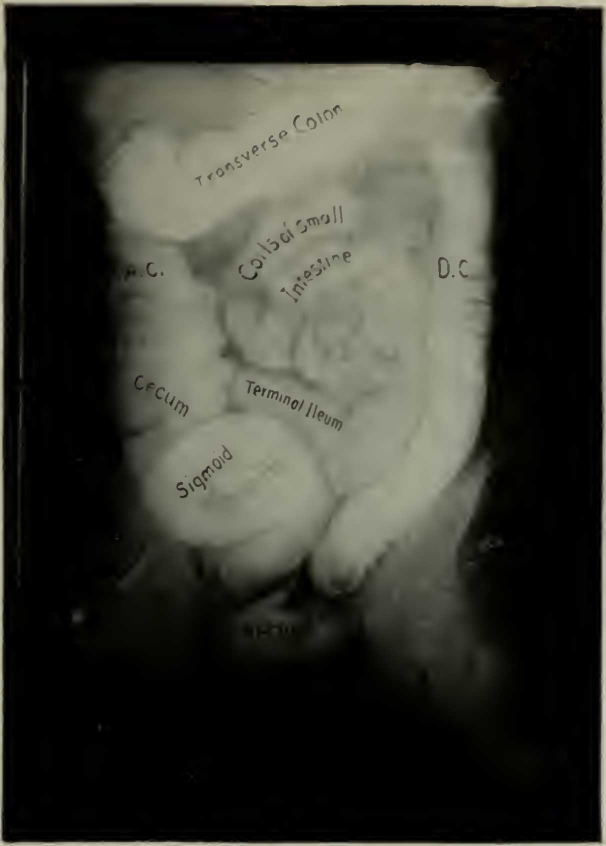

FIG. 29.—ROENTGENOGRAM ILLUSTRATING FILLING OF SMALL INTESTINE WITH BARIUM ENEMA.

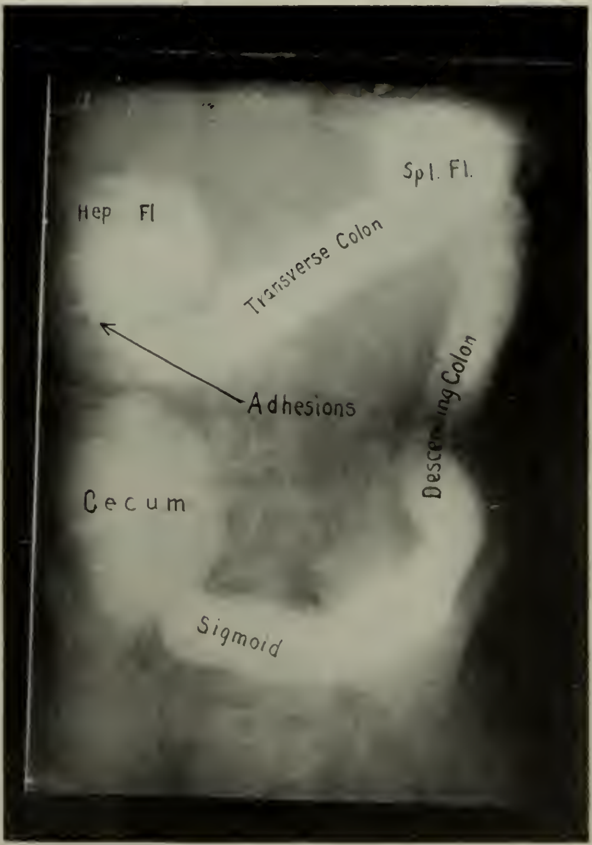

FIG. 30.—CASE 19. JACKSON'S MEMBRANE CAUSING PARTIAL OBSTRUCTION JUST DISTAL TO HEPATIC FLEXURE AND RESULTING IN DILATATION OF HEPATIC FLEXURE AND CECUM.

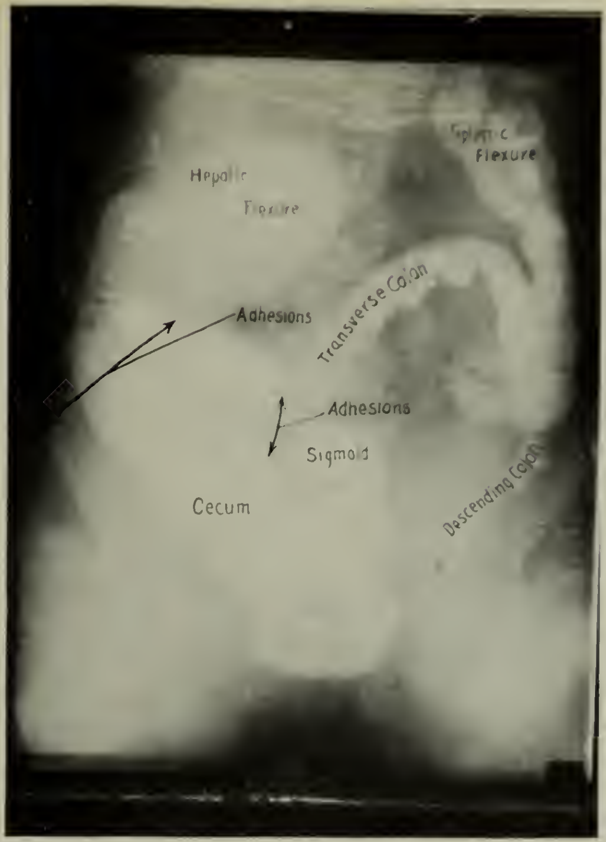

FIG. 31.—CASE 20. ADHESIONS CAUSING KINKING AND FIXATION OF POINTS ON TRANSVERSE COLON RESULTING IN DILATATION OF HEPATIC FLEXURE AND CECUM.

Note the spastic condition and redundancy of the descending colon.

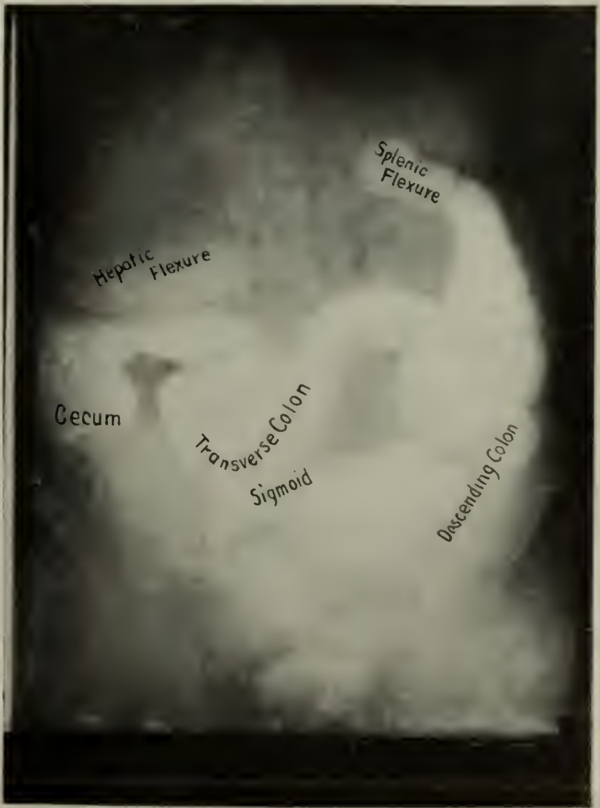

FIG. 31a.—CASE 20. SAME CASE AS FIG. 31 AFTER OPERATION. CECUM AND HEPATIC FLEXURE REDUCED TO NORMAL SIZE.

Colon redundant but there is no unusual fixation of any of the coils.

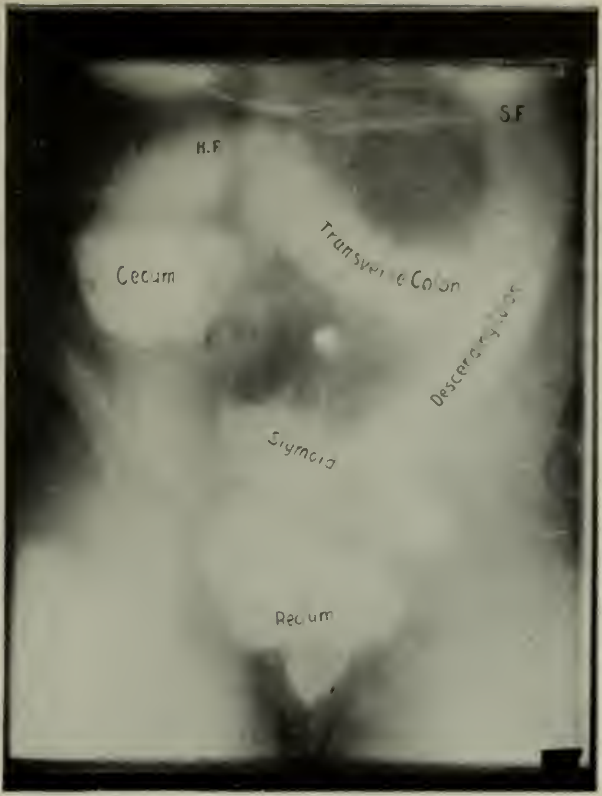

FIG. 32.—CASE 21. FIXATION OF CECUM WITH ANGULATION OF LOWER END. FIXATION OF TRANSVERSE COLON JUST DISTAL TO HEPATIC FLEXURE CAUSING PARTIAL OBSTRUCTION.

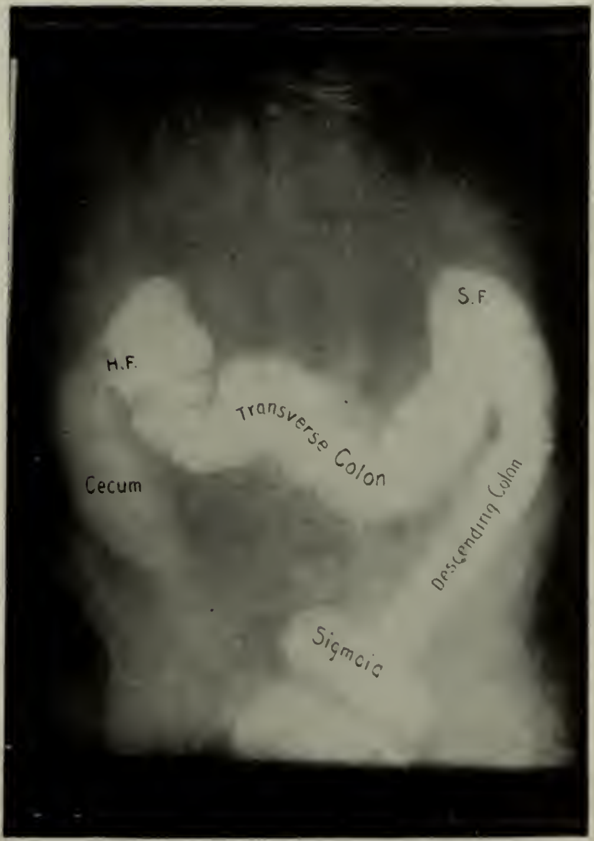

FIG. 32a.—CASE 21. AFTER OPERATION.

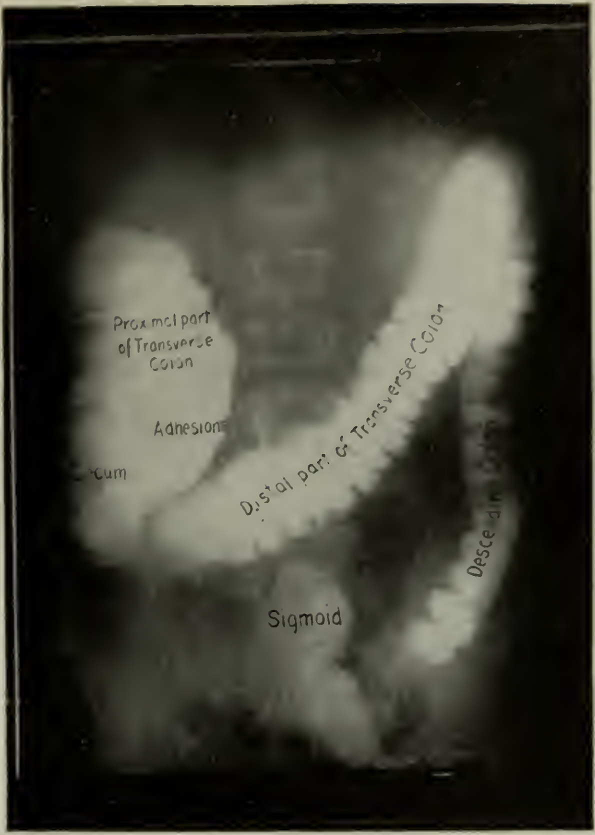
Proximal part of Transverse Colon
Adhesions
Cecum
Distal part of Transverse Colon
Descending Colon
Sigmoid

FIG. 33.—CASE 22. ADHESIONS OF PROXIMAL PORTION TRANSVERSE COLON TO WHOLE EXTENT OF ASCENDING COLON AND CECUM.

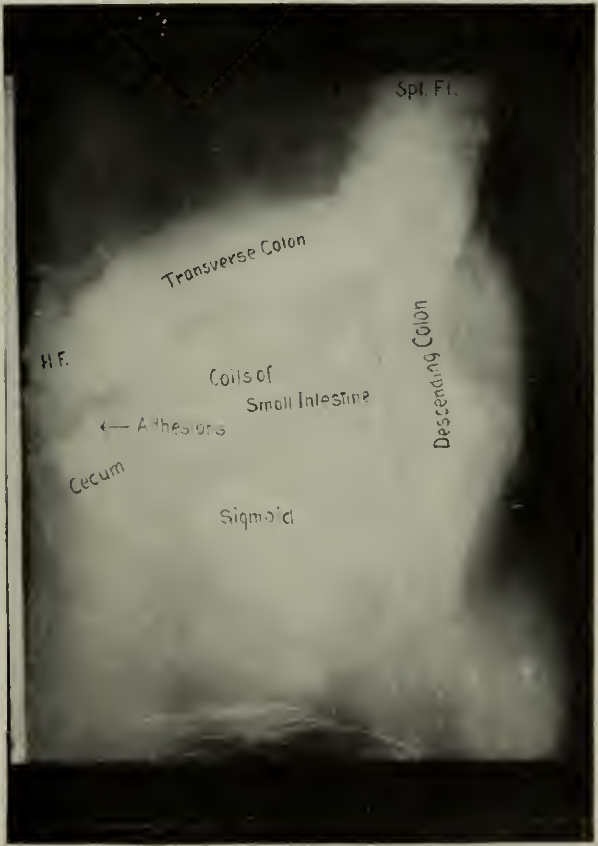

FIG. 34.—CASE 23. CONTRACTION AND DEFORMITY OF CECUM DUE TO ADHESIONS OF INFLAMMATORY ORIGIN.

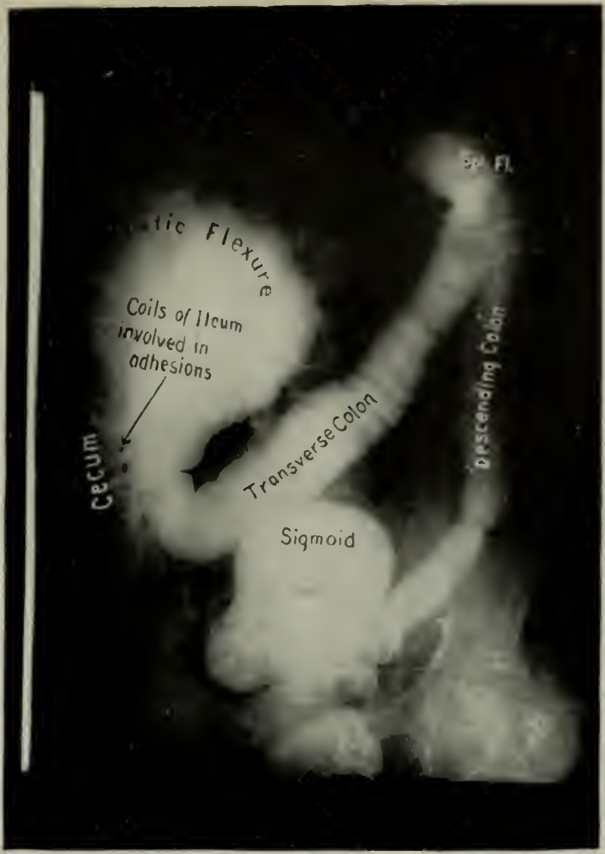

FIG. 35.—CASE 24. ADHESIONS CAUSING FIXATION OF TRANSVERSE COLON TO WHOLE EXTENT OF DESCENDING COLON AND CECUM.

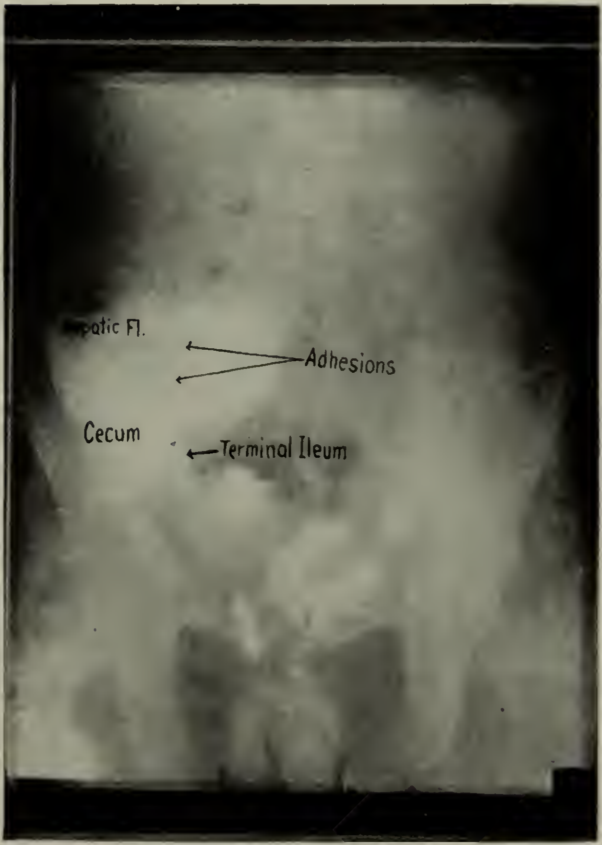

FIG. 35a.—CASE 24. TWENTY-FOUR HOURS AFTER INGESTION OF BISMUTH MEAL.

Some bismuth still in the ileum.

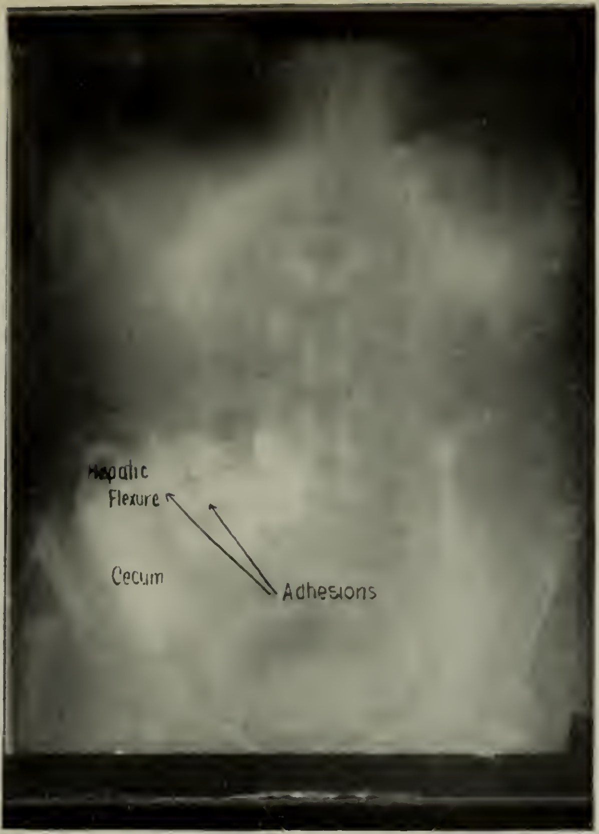

FIG. 35b.—CASE 24. FORTY-EIGHT HOURS AFTER INGESTION OF BISMUTH MEAL.

Much of the bismuth meal is still in the cecum and the hepatic flexure.

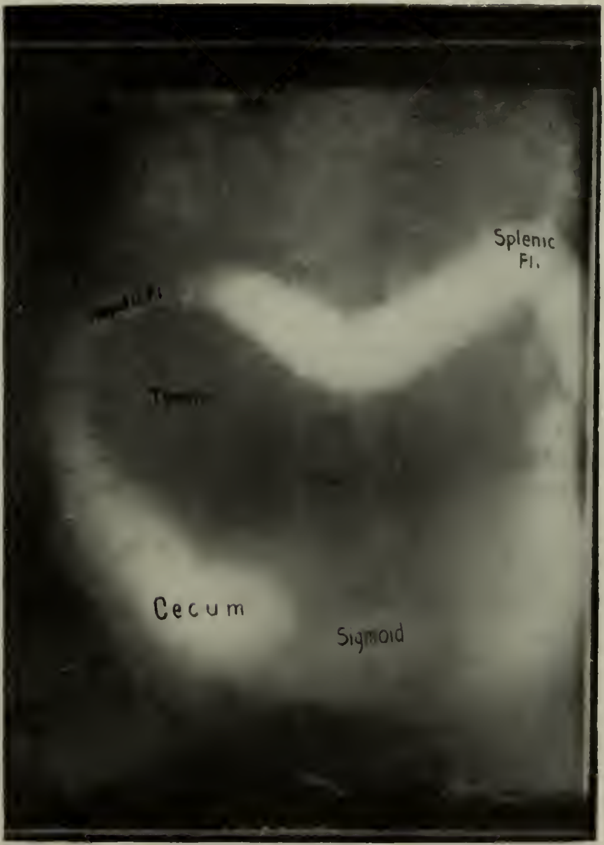

FIG. 36.—PRESSURE OF LARGE TUMOR (CYSTIC KIDNEY) UPON HEPATIC FLEXURE COLON.

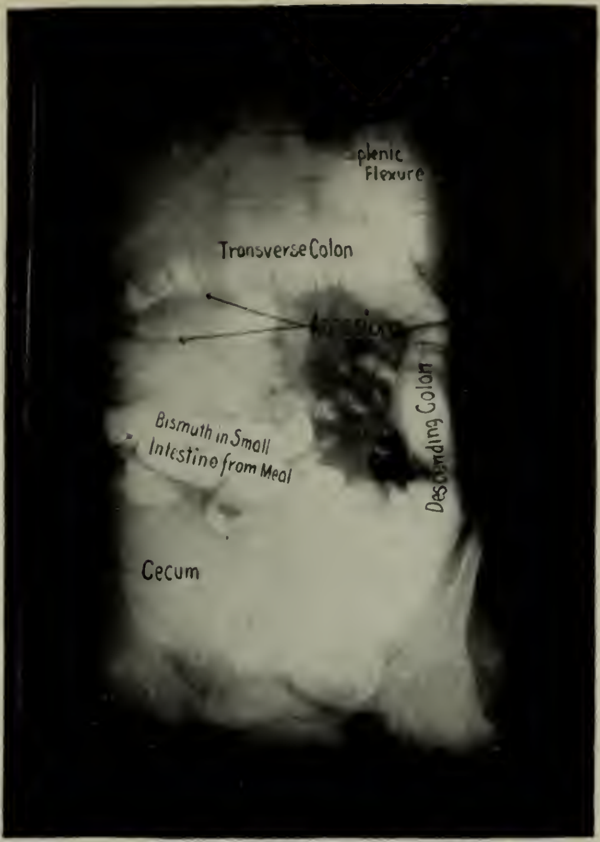

FIG. 37.—CASE 25. REDUPLICATION AND FIXATION OF FOLDS OF COLON CAUSING PARTIAL OBSTRUCTION NEAR HEPATIC FLEXURE.

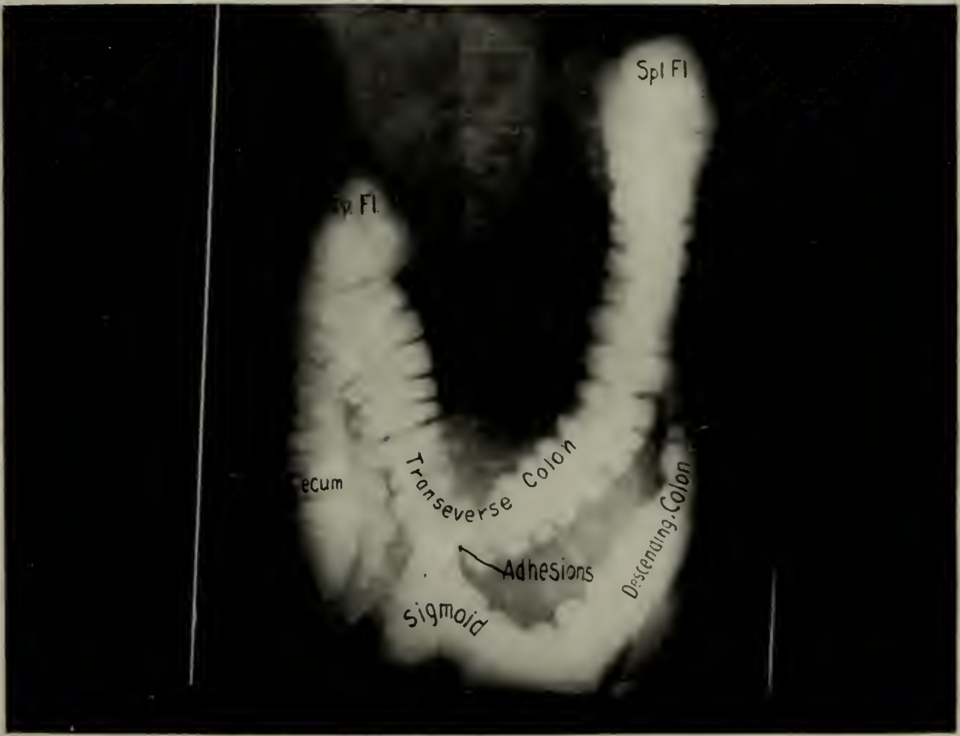

FIG. 38.—CASE 26. TRANSVERSE COLON ADHERENT TO SIGMOID. PRONE POSITION.

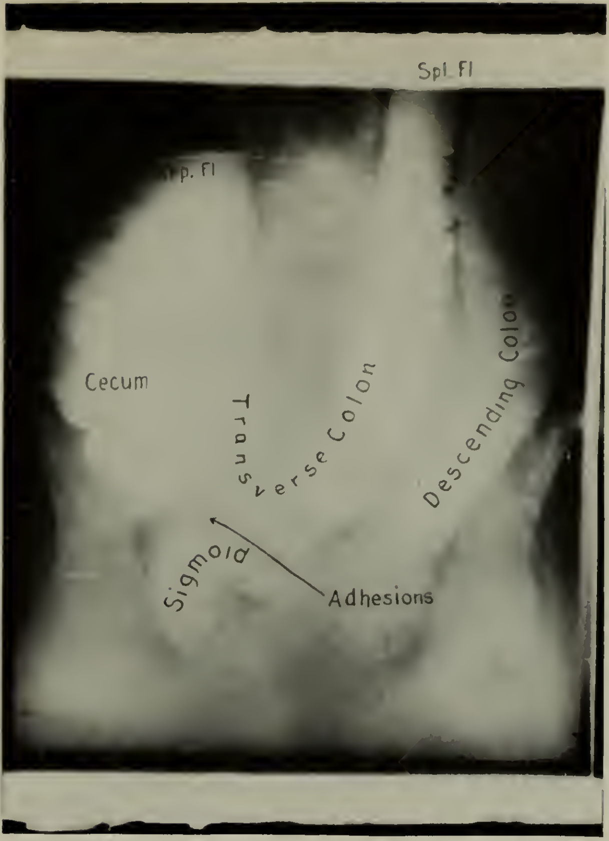

FIG. 38a.—CASE 26. ERECT POSITION.

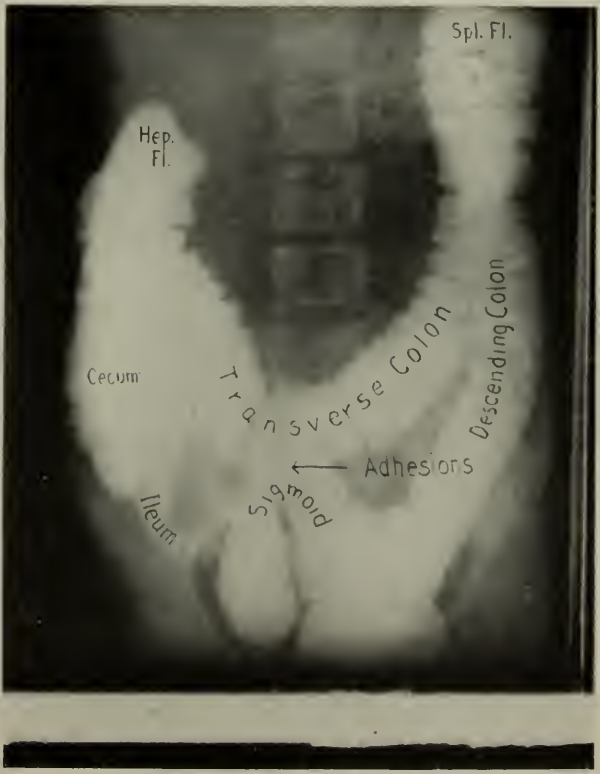

FIG. 38b.—CASE 26. TRENDELENBURG POSITION.

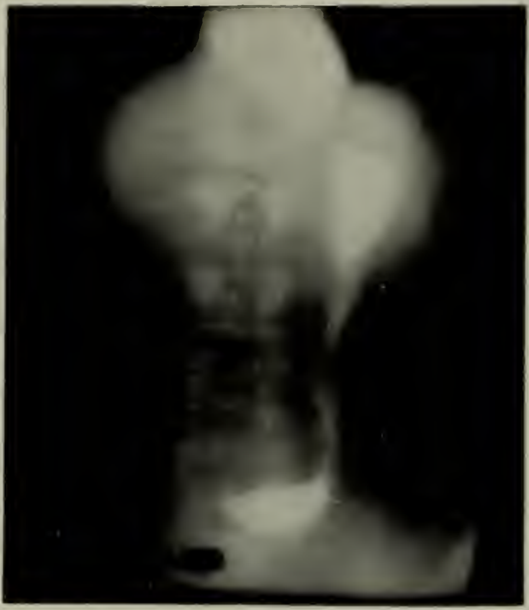

FIG. 39.—OBSTRUCTION AT CARDIAC END OF STOMACH WITH DILATATION OF ESOPHAGUS.

Patient died of pulmonary tuberculosis about 9 months after this picture was made.

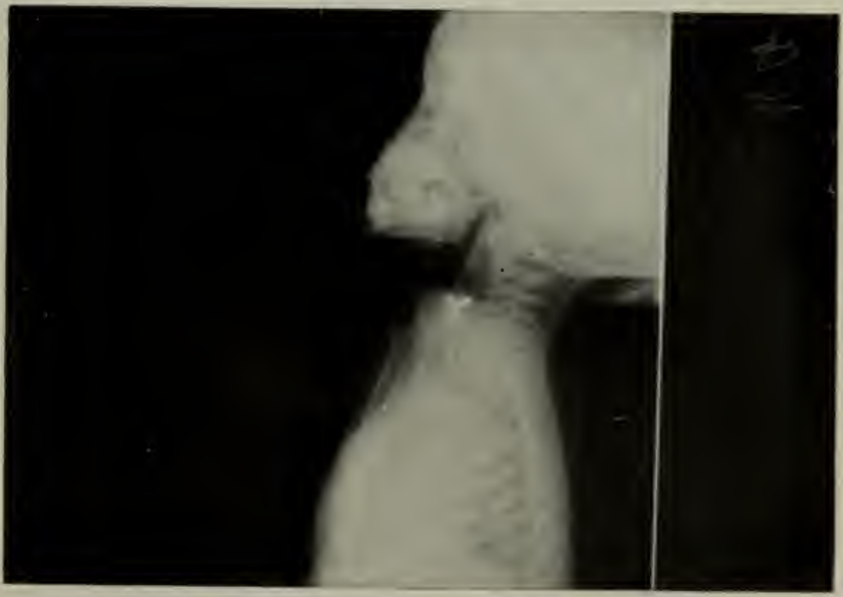

FIG. 40.—CASE 27. BRASS RIVET IN UPPER END OF ESOPHAGUS. BAR OF RIVET EMBEDDED IN SOFT TISSUES.

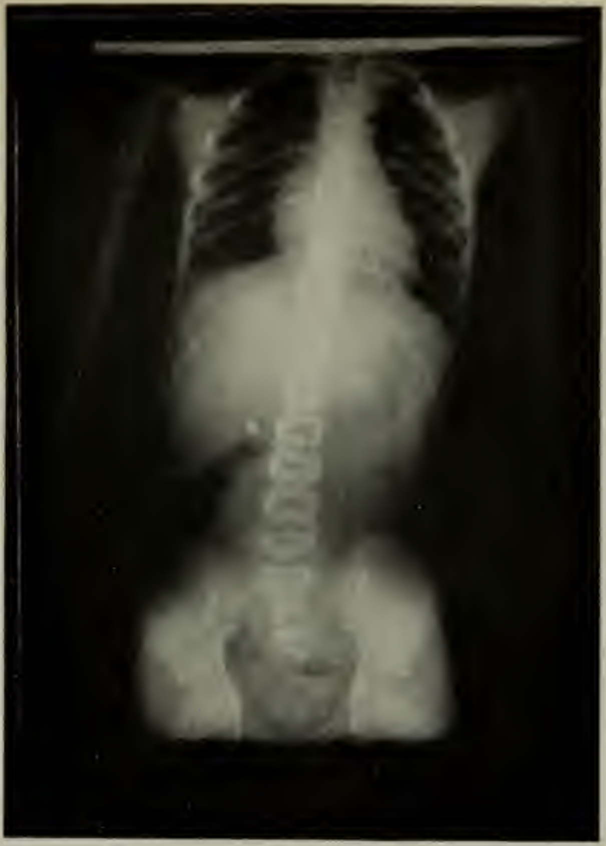

FIG. 41.—PORCELAIN-HEADED PIN IN GASTRO-INTESTINAL TRACT, PROBABLY IN UPPER PART OF SMALL INTESTINE. NO SYMPTOMS.

Was swallowed 8 days before roentgenogram was made.

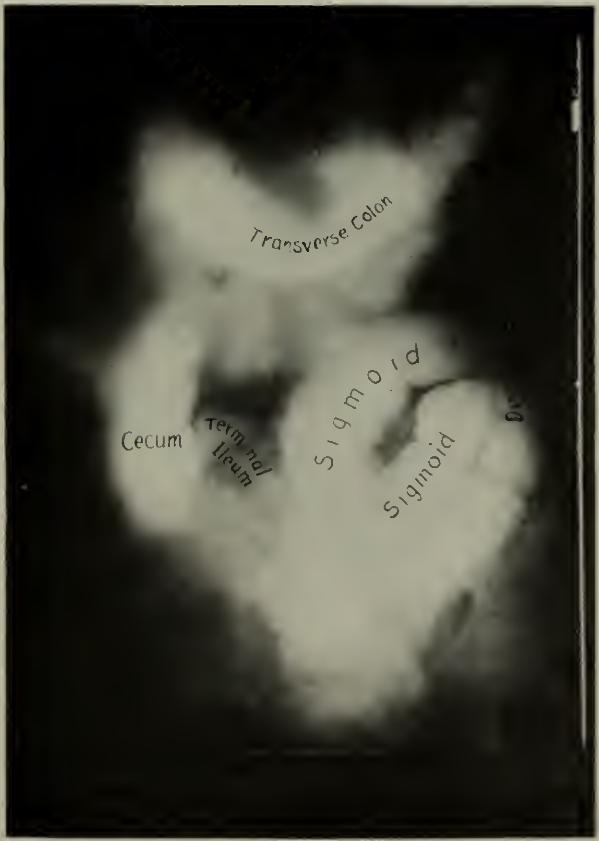

FIG. 42.—LONG SIGMOID ADHERENT TO DESCENDING COLON.

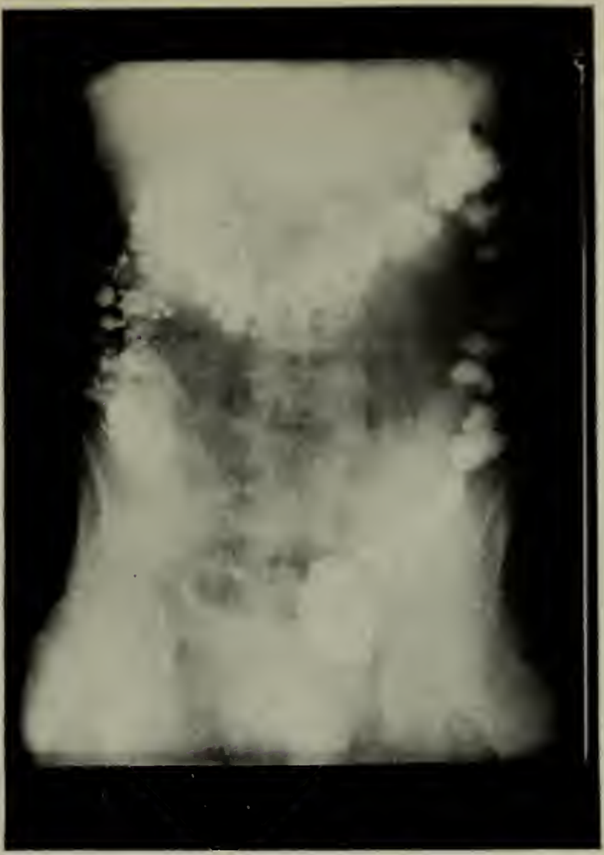

FIG. 43.—APPEARANCE OF COLON IN SPASTIC CONSTIPATION, AFTER BISMUTH MEAL.

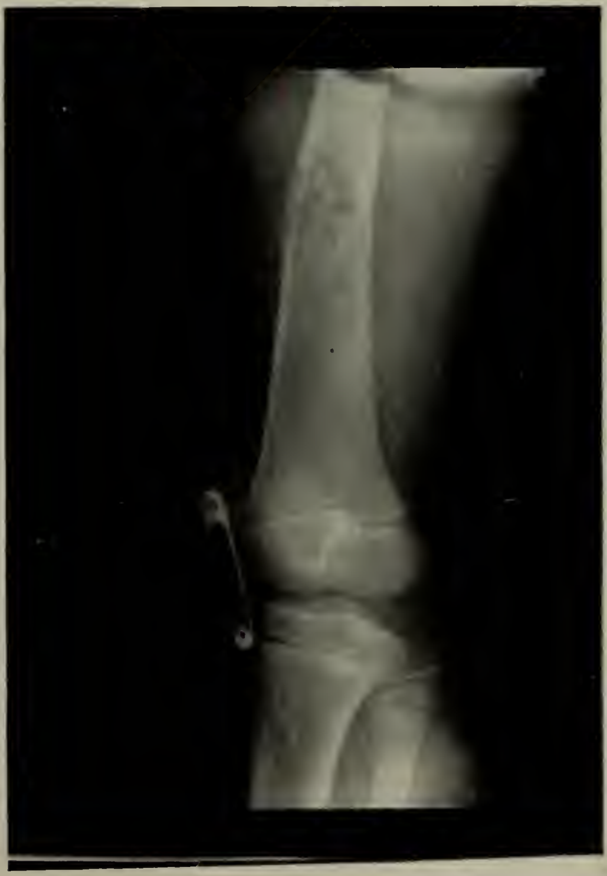

FIG. 44.—CASE 28. NOVEMBER 11, 1913. OBLIQUE FRACTURE THROUGH CYST OF FEMUR.

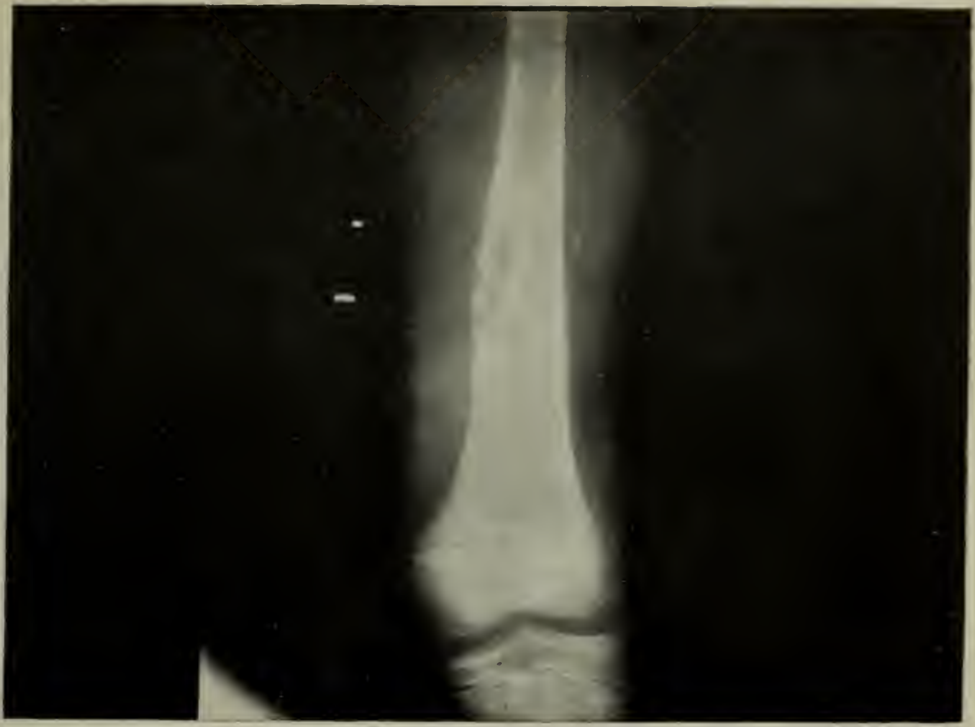

FIG. 44a.—CASE 28. DECEMBER 9, 1913. LATERAL VIEW. FRACTURE SHOWS BELOW THE CYST.

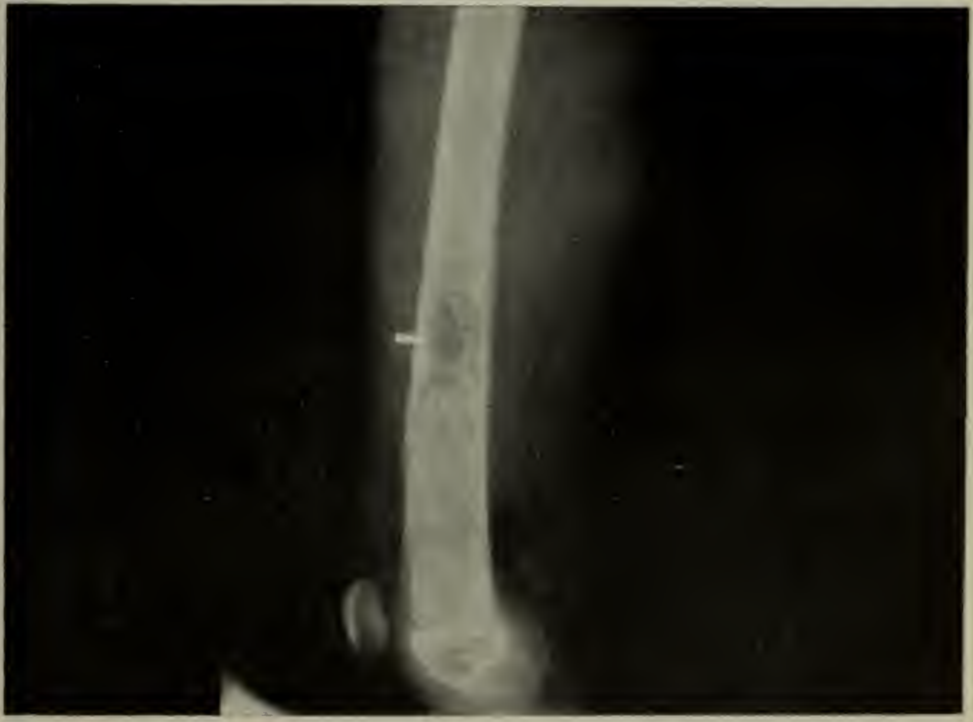

FIG. 44b.—CASE 28. DECEMBER 9, 1913. ANTEROPOSTERIOR VIEW.

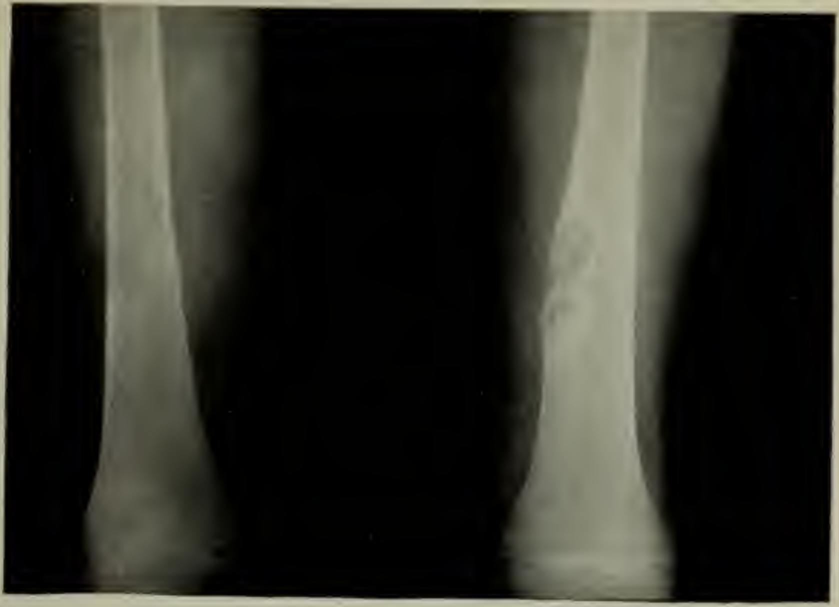

FIG. 44c.—CASE 28. FEBRUARY 9, 1914. BEFORE OPERATION.

Notice the thickening of the shaft above and below the cyst as compared with bone of other leg.

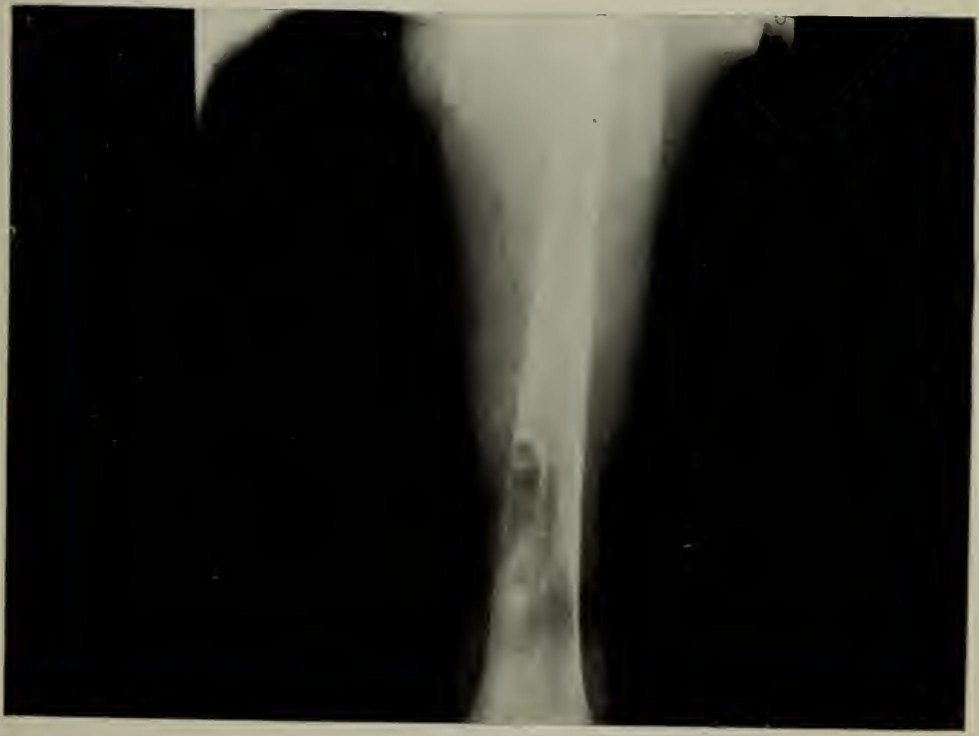

FIG. 44d.—CASE 28. APRIL 21, 1914. FOUR WEEKS AFTER OPERATION.

Notice shell of bone along outer edge and bridges across the cavity.

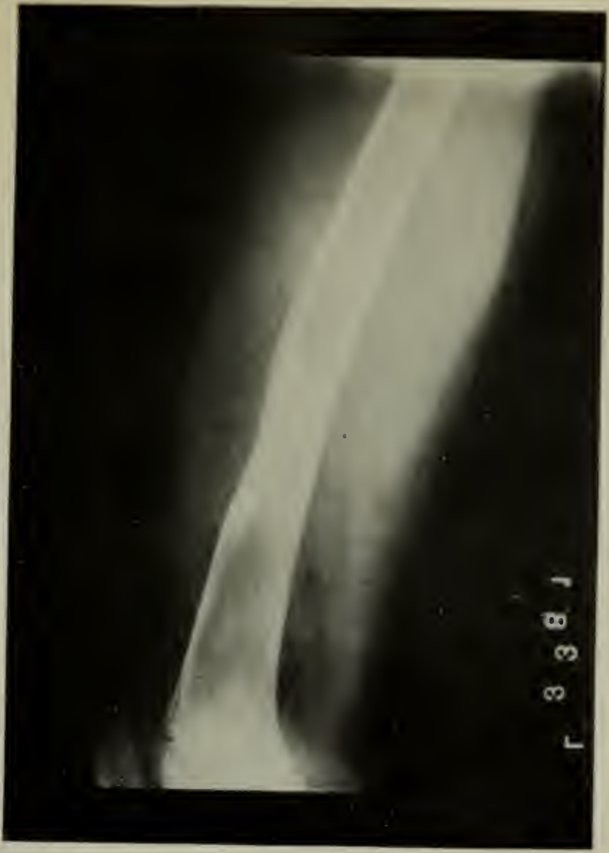

FIG. 44e.—CASE 28. JULY 28, 1914. LATERAL VIEW.

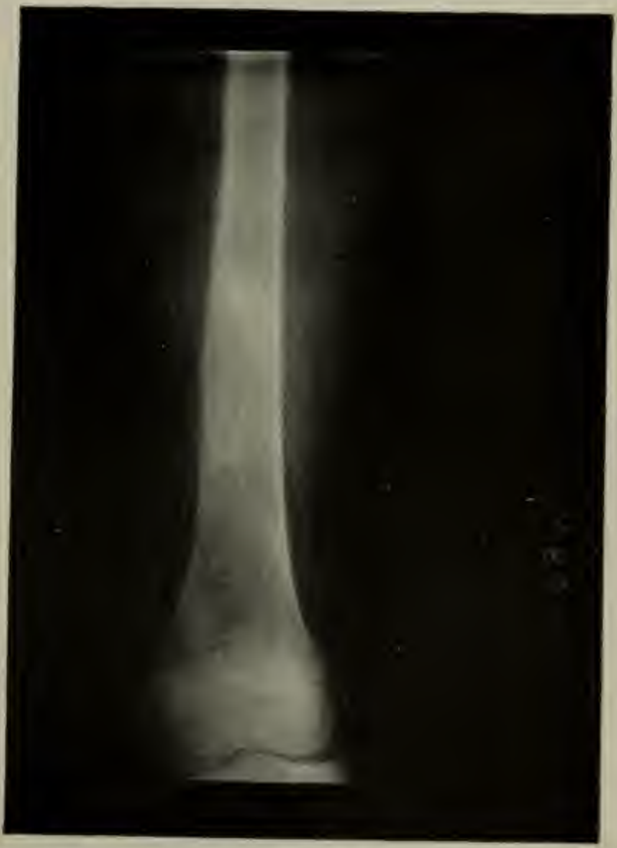

FIG. 44f.—CASE 28. JULY 28, 1914. ANTERO-POSTERIOR VIEW.

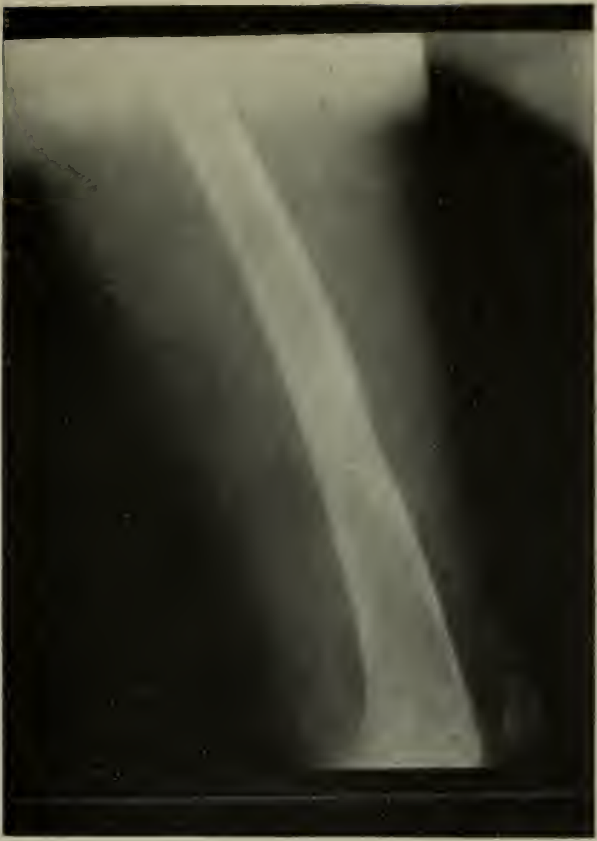

FIG. 44g.—CASE 28. AUGUST 28, 1914. LATERAL VIEW.

There is now no evidence of the cyst and a very slight depression at site of operation.

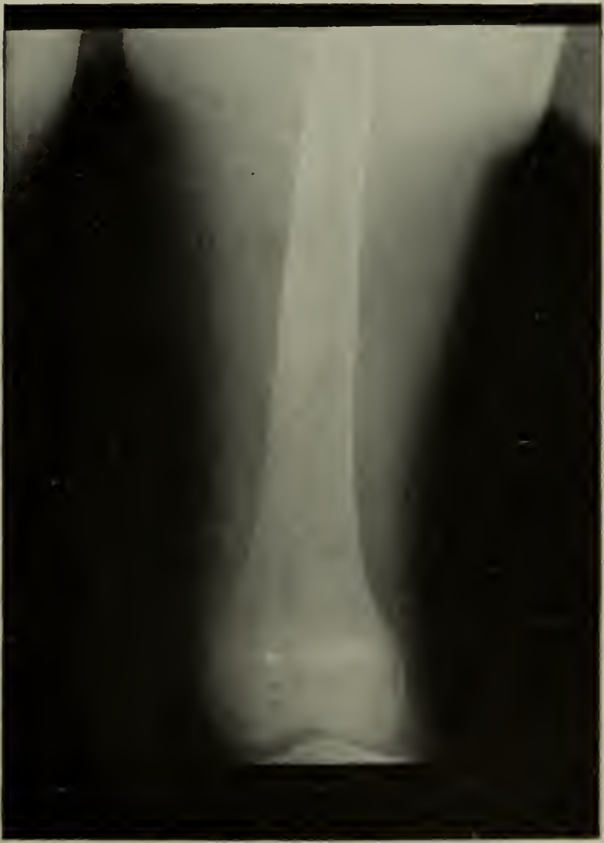

FIG. 44h.—CASE 28. AUGUST 28, 1914. ANTERO-POSTERIOR VIEW.

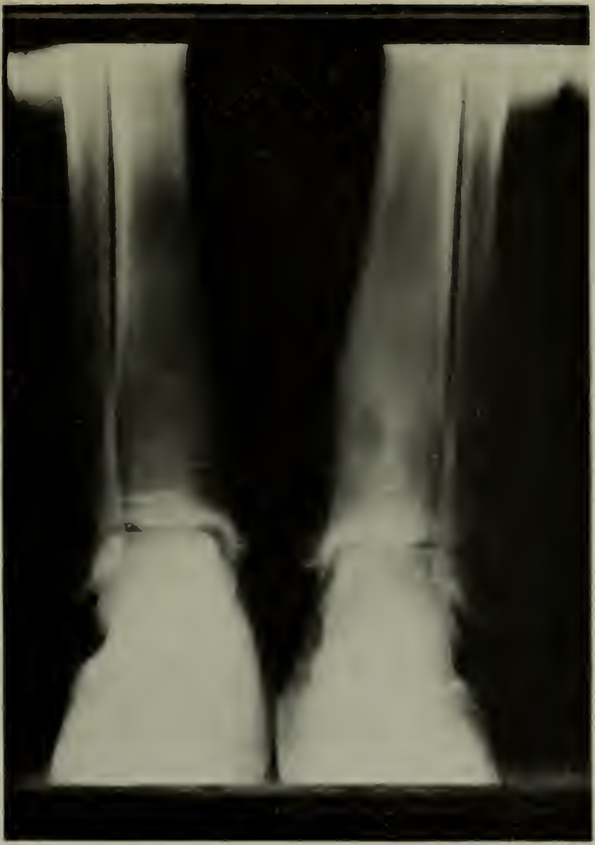

FIG. 45.—CASE 29. BRODIE'S ABSCESS, LEFT TIBIA.

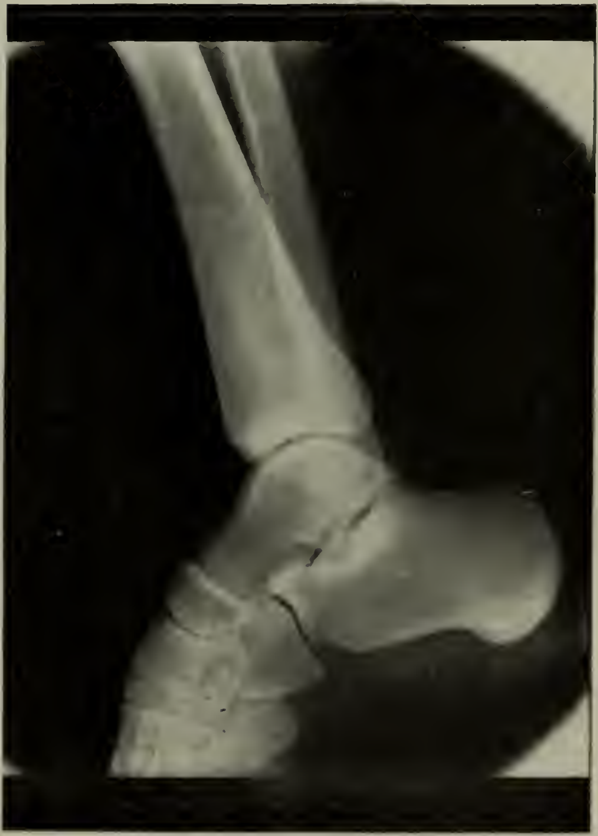

FIG. 45a.—CASE 29. BRODIE'S ABSCESS, LEFT TIBIA. LATERAL VIEW.

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THE PREVALENCE OF SYPHILIS IN THE ARMY

BY

EDWARD B. VEDDER
Captain, Medical Corps

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JUNE, 1915

Medical

THE PREVALENCE OF SYPHILIS IN THE ARMY

BY

EDWARD B. VEDDER
Captain, Medical Corps

PUBLISHED BY AUTHORITY OF THE ACT OF CONGRESS APPROVED AUGUST 1, 1914, AND WITH THE APPROVAL OF THE SECRETARY OF WAR, FOR THE INFORMATION OF MEDICAL OFFICERS

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CONTENTS.

Page.
Introduction 5

Part I. The Prevalence of Syphilis Among Men Just Entering the Service.
  1. The Prevalence of Syphilis Among Recruits 19
  2. The Prevalence of Syphilis Among Cadets at West Point 28

Part II. The Prevalence of Syphilis Among Soldiers in the Army.
  1. The Prevalence of Syphilis Among White Enlisted Men 31
  2. The Prevalence of Syphilis Among Colored Enlisted Men 38
  3. The Prevalence of Syphilis Among Enlisted Men of the Porto Rico Regiment 45

Part III. The Prevalence of Syphilis Among Soldiers That Have Recently Left the Service.
  1. The Prevalence of Syphilis Among Military Convicts 53
  2. The Prevalence of Syphilis Among Insane Soldiers at the Government Hospital for the Insane, Washington, D. C 57
  3. The Prevalence of Syphilis Among the Tuberculous Soldiers at the General Hospital, Fort Bayard, N. Mex 60
  4. The Prevalence of Syphilis Among the Inmates of the U. S. Soldiers' Home, Washington, D. C 65
  5. The Relative Prevalence of Syphilis Among Soldiers That Have Left the Service as Indicated by a Study of the Syphilitic Registers 73

Part IV. Conclusions and the Practical Considerations Suggested by This Study.
  1. Summary and Conclusions 77
  2. The Prevention of Syphilis in the Military Service 79
  3. The Standardization of the Wassermann Reaction in the Military Service 94

INTRODUCTION.

The Wassermann reaction has been used continuously as an aid in the diagnosis of syphilis in the Army since 1909. As a result, much information has been obtained both with regard to the technique and interpretation of the Wassermann reaction and with regard to the nature of syphilis. Bulletin No. 3, Office of the Surgeon General, United States Army, entitled "Studies of Syphilis," by Capt. Charles F. Craig, Medical Corps, and Capt. Henry J. Nichols, Medical Corps, presents some of the experience so obtained, and deals with a number of diverse aspects of the subject of syphilis, including the diagnosis of syphilis by the Wassermann reaction; the interpretation of this test; the influence of treatment with salvarsan upon the Wassermann reaction; nervous relapses; the standard for cure; and other questions relating to the study of syphilis.

It occurred to the writer that, since the technique and interpretation of the Wassermann reaction had been placed on such a firm basis, it would be instructive to apply this very efficient instrument for the acquisition of information as to the prevalence of syphilis in the Army. This has been done by means of a series of Wassermann surveys, and the results of this work are given in this bulletin.

Necessarily the cooperation of a number of medical officers was essential for the successful performance of this task. Many have assisted in the collection of blood specimens and data, and I have endeavored to mention these officers in the proper place. I am much indebted to these officers for the performance of this tedious and uninteresting work.

That this work has been possible at all is due to Surg. Gen. William C. Gorgas and to Maj. William J. L. Lyster, Medical Corps, of the Office of the Surgeon General. Unless one has undertaken work of this character, it is difficult to realize the number of objections that can be urged against it and the annoying complications that prevent the collection of blood specimens and data. It has required no little time and effort on the part of Gen. Gorgas and Maj. Lyster to remove these difficulties, and I desire here to express my hearty appreciation of the interest they have taken in this work.

Some remarks may be useful in explaining the method pursued. The purpose of the investigation was to determine the prevalence and distribution of syphilis in the Army. A complete syphilitic survey of the entire Army—i. e., a study of every man in the Army—was, of course, impossible, nor was it necessary. While the incidence of syphilis varies considerably in the different classes in a community, the Army is much more homogeneous than any civilian community, and is much more readily considered as a whole. Still differences, of course, do occur, conditioned chiefly upon race, rank, and length of service. It was therefore decided to approach the subject by studying groups, which for convenience may be classified as follows:

1. Those just entering the service. This group is considered in part 1, and includes both the enlisted and the commissioned personnel.

2. Those who have been in the service some time. This group consists entirely of enlisted men, since it was impracticable to secure a survey of commissioned officers. The whites, negroes, and Porto Ricans were studied separately. It would have been most interesting if the Philippine Scouts could have been included in this study, but this was omitted because of the difficulty of obtaining a survey on men at such a great distance.

3. Those who have recently left the service. This group is subdivided, depending upon the method by which the men became separated from the service. This is a natural classification, since it would be suspected that syphilis would be more prevalent among soldiers discharged on certificates of disability for insanity than among those honorably discharged at the expiration of their term of enlistment. It is unfortunate that no survey of the latter is obtainable, since it is naturally impossible to continue observation of these men after they have left the service. This group is, therefore, limited to enlisted men that have been sent to one of the Government institutions after discharge. However, an attempt to determine the prevalence of syphilis among honorably discharged soldiers as compared with these other groups has been made by means of a study of the syphilitic registers of all discharged soldiers.

In order to avoid the fallacies inherent in the consideration of a small number of cases it was intended that each group should consist of 1,000 men. This was a convenient number, large enough to avoid error, and not too large to become a matter of burdensome and useless accumulation of statistics. The results obtained by making differential leucocyte counts illustrates this point. If several observers each count 100 cells, the differences on a percentage basis will be considerable. If they each count 200, this error is greatly reduced: if they each count 500, there is never any essential difference, and if they each count 1,000, the percentages will commonly agree down to the second decimal. Any counting beyond this number is an unnecessary refinement, and, indeed, for practical purposes of diagnosis, more than 500 cells are seldom counted. It was, therefore, believed that it would be quite fair to estimate the percentage of syphilis in a certain group by taking 1,000 men at random from that group, and that the percentage in any other thousand men from the same group would not differ markedly from the thousand studied.

As a matter of fact, while 1,000 men was thus the unit always sought for, in a few cases more than a thousand men were obtained, while in other cases, for various reasons which it is unnecessary to detail, 1,000 could not be obtained, and it was necessary to use the number that could be secured.

In endeavoring to determine the amount of syphilis in the groups studied, we have depended chiefly upon Wassermann surveys, although whenever possible these surveys have been reenforced by the clinical examination. The efficiency of the Wassermann reaction as we have used it in detecting syphilis should therefore be discussed.

The accuracy and efficiency of the Wassermann reaction depend upon two factors—the person performing the reaction and the method used. It is therefore proper to state that all of the reactions reported in this bulletin were performed personally by the writer with the assistance of Sergt. Frederick G. Abner, Hospital Corps, and I wish to take this occasion to express my appreciation of the hard and faithful work that Sergt. Abner has contributed to this piece of work.

Throughout all the work we have used the modification of the original Wassermann reaction described by Craig in Bulletin No. 3, page 72. Since the technique has been very fully described in that bulletin, it is only necessary to state here that it differs from the original Wassermann reaction in the use of a human hæmolytic system in place of a sheep hæmolytic system, and in a proportional reduction in the quantities of reagents used.

After a fair amount of experience with the original Wassermann system and Craig's modification, it is my belief that the selection of a hæmolytic system is chiefly a matter of convenience, and that either system works equally well when properly controlled. As a matter of fact, however, the use of the human system obviates the necessity for making elaborate controls to determine the presence of natural sheep amboceptor in the sera to be tested, and is therefore more convenient on that account, and, further, human blood is very readily obtained in this laboratory while sheep blood is only procured with the greatest difficulty.

I wish to emphasize here the necessity for titrating the complement prior to performing the test. Boas (1) stated recently "that great variations in the strength of complement are not so common as is often stated. In the investigation of more than 100 guinea-pig sera I have found variations of only 0.07–0.04 c. c. in the smallest complete hæmolytic dose. In most cases the smallest complete hæmolytic dose was 0.05 c. c." Again, Kaplan (2), who at any rate makes no mention of the titration of the complement, makes the statement that the activity of the hæmolytic amboceptor varied from day to day with the barometric pressure. A much more probable explanation of this variation consists in the variation in the complement which so many observers have noticed, and which was apparently used in a fixed dose without titration. This point is mentioned because we have met with great variations in the strength of the complement from different guinea pigs and even between the pooled complements from several guinea pigs. It is a matter of surprise, therefore, that so many workers have used complement without titration, and one is impressed by the fact that the Wassermann reaction must actually be a test of most surprising merit in order to have survived all the clumsy technique that has been perpetrated in its name. It is needless to state that the complement has invariably been titrated in this laboratory, and used in the quantity indicated by the titration.

The efficiency or inefficiency of the Wassermann reaction in detecting syphilis depends chiefly upon the antigen used. We have used as antigen an alcoholic extract of human heart fortified with 0.4 per cent cholesterin, and this has been our only variation from the technique described by Craig (loc. cit), who at that time used an alcoholic extract of syphilitic fœtal liver. Without entering into a detailed discussion of the relative merits of different antigens, it will be sufficient to state here that I believe that while certain extracts of syphilitic fœtal liver may be very efficient, yet these extracts vary greatly in antigenic power, some of them being comparatively weak. In our experience this has rarely been the case with the extracts of human heart fortified with cholesterin. This antigen appears to be more uniform in its ability to fix complement in the presence of syphilitic antibodies, whatever they may be, than any other antigen we have tried. It comes nearer, therefore, to being a standard antigen than anything else at our disposal at present, and for that reason has been used in all tests reported here. It goes without saying that controls have always been used, consisting of anticomplementary controls for each serum tested, anticomplementary controls of the antigen alone, and the antigen has also been tested each day with known positive and negative sera.

The question of nonspecific fixation with this antigen at once arises. Thomas and Ivy (3) have recently criticized the use of this antigen, stating that "we must conclude that with cholesterinized antigens varying degrees of inhibition of hæmolysis may be obtained in serums from many conditions other than syphilis and in normal persons."

However, these workers themselves are to be criticized, since in the tests by which they condemned this antigen they used a hæmolytic system containing only one unit of complement and hæmolytic amboceptor instead of the two units almost universally used by other workers. It appears to be generally accepted that it is desirable to use two units of complement and amboceptor in the performance of the Wassermann reaction. But even if this were not the case it is manifestly unfair to the antigen and to the workers who introduced it to condemn the antigen by tests conducted with such a radical modification of technique.

On the other hand, this antigen has been highly praised by such workers as McIntosh and Fildes (4), Walker and Swift (5), Thompson (6), Field (7) (8), Walker (9), Kolmer and Schamberg (10), and others.

Cornwall (11) has recently studied the efficiency of cholesterinized antigens as compared with other antigens in a series of 1,500 tests, and concludes that cholesterinized antigens are superior to simple alcoholic tissue extracts and acetone insoluble lipoidal antigens for the detection of syphilis in any stage. With the cholesterinized antigens 11 per cent more positive results are obtained.

It is, however, more to the point to investigate the actual results obtained from the use of this antigen in the Wassermann reaction as performed in these tests.

Fortunately several good checks on the accuracy of the results of these surveys are at hand. In the first place, while this survey work was being performed, on each day a number of routine tests were also performed. Since a brief history is sent in for each of these cases, we are able to state just what the Wassermann reaction in our hands has been doing. Thus during the year ended June 30, 1914, the total number of Wassermann tests made in this laboratory has been 7,914, of which 2,590 were reexaminations for confirmation or to control the result of treatment, 3,326 were survey cases included in this report, and 1,998 were examinations of new cases. Of the latter, 949 were of syphilis or suspected syphilis and 1,049 were from cases suffering with diseases other than syphilis. The following table shows the actual results obtained in the 949 cases of syphilis or suspected syphilis:

TABLE I.

Stage of disease.	Number of cases.	Positive.	Negative.	Per cent positive.
Primary	242	178	64	73.55
Secondary	310	285	25	91.93
Tertiary	263	227	36	86.31
Latent	114	92	22	80.70
Not classified	20	16	4	80.00
Total	949	798	151	84.09

With regard to the 1,049 examinations of cases suffering from other diseases, it should be stated that among all of these tests there were only 4 double plus reactions. Two of these were from cases of diabetes; 1 was from a long-standing case of necrosis of the vertebræ, probably tubercular, and in whom syphilis was not probably present, though it could not be definitely excluded. One case was in a normal individual in whose case syphilis could certainly be excluded. This last reaction was probably due to an error in technique. But counting all four reactions as false positives, it is seen that at most they only amount to 0.4 per cent out of more than a thousand examinations. Plus and plus minus reactions, particularly the latter, are of much less significance. Plus reactions were returned in about 1.1 per cent of these 1,049 cases, and 10.1 per cent gave a plus minus reaction.

Another excellent check on the reaction in primary syphilis was obtained from a series of chancres studied in conjunction with Capt. Nichols, Medical Corps. Capt. Nichols made a dark-field examination for Treponema pallidum, took the blood, and the Wassermann was made by the writer, usually without any knowledge as to the nature of the case. The results in 31 chancres so studied are shown in the following table. It may be remarked that a positive Wassermann was never returned in any case in which subsequent investigation did not show that the sore was a chancre. In the two cases in which both the Wassermann and the dark-field examination failed, the diagnosis was made by the subsequent appearance of secondaries.

Duration of sore.	Dark field.	Wassermann.
2 days	+	−
3 days	+	−
7 days	+	−
7 days	+	−
10 days	+	−
2 weeks	+	−
2 weeks	+	−
3 weeks	+	+ −
3 weeks	+	−
3 weeks	+	−
1 month	+	−
1 week	−	+ +
1 week	−	+
2 weeks	−	+ +
3 weeks	−	+
1 month	−	+ +
1 month	−	+ +
7 days	+	+ +
9 days	+	+
14 days	+	+
15 days	+	+
1 month	+	+ +
1 month	+	+
1 month	+	+ +
1 month	+	+ +
1 month	+	+ +
1 month	+	+ +
1½ months	+	+ +
2 months	+	+ +
1 month	−	−
1 month	−	−

This series of 31 chancres consists of cases taken just as they came and affords a good illustration of the ease and certainty with which the diagnosis of primary syphilis may be usually made when both dark field and Wassermann are used. Also how one frequently fails where the other is positive. Many of these were typical chancres clinically, but many of them were atypical and would have passed for chancroids. This is particularly true of the two cases in which a diagnosis was not made. These sores were clinically more like chancroids. The Wassermann being negative, and search having failed to show spirochætes, the cases were diagnosed chancroids, and, much to our chagrin, both returned with secondary syphilis. This points the moral that if a dark-field examination is negative, it should be repeated several times before chancre is excluded.

However, the reason for introducing this series at this point is to show that of 31 chancres taken just as they came, a positive Wassermann was secured in 18, or 58 per cent. If all cases of less duration than one week were excluded, this percentage would be higher. This series of cases corroborates the figures already given with regard to the efficiency of the Wassermann reaction as performed in this laboratory.

A further index of the efficiency and accuracy of these tests is afforded in a series of parallel tests, in which the Wassermann reaction was performed independently by this laboratory, by the laboratory of the Post-Graduate Medical School in New York, and by the laboratory of the New York Board of Health. Thus, in a series of 500 tests, all three laboratories gave the same report in 299 cases. Of these 299, 215 were negative reactions, 1 was a 1 +, 1 was a 2 +, and 84 were 4 + reactions. There were, therefore, 201 sera in which differences were reported. Of these 201 sera, 166 consisted of differences in the degree of reaction in known syphilitics (+ + in one laboratory, + + + in another, or + + + in one laboratory and + + + + in another), or in treated cases (+ in one laboratory, + + in another, etc.), or in negative cases (+ — in one laboratory, — in another, etc.). These variations in the degree of the reaction were too slight to mislead the clinician who has had experience enough with the reaction to interpret it correctly.

This leaves 34 cases out of the 500 in which a material discrepancy occurred. Of these there were 9 cases in which the clinical data obtainable is insufficient to determine which laboratory gave the correct report. The remaining cases may be classified as follows:

1. Army laboratory negative; history positive and (1) one other laboratory positive. Five cases. (2) Both other laboratories positive. Five cases.
2. Army laboratory positive; history negative and (1) one other laboratory negative. None. (2) Two other laboratories negative. Five cases.
3. Army laboratory positive; history positive and (1) one other laboratory negative. Three cases. (2) Two other laboratories negative. Two cases.
4. Army laboratory negative; history negative and (1) one other laboratory positive. Five cases. (2) Two other laboratories positive. One case.

From the present point of view failure of the Army laboratory to detect syphilis is of little importance. But it would be a serious matter if a large number of false positives were reported. It will be seen from the above that the positive reactions in supposed negative cases were about equally distributed among the different laboratories, and that so far as the Army is concerned there are only 5 such cases out of the 500. It is possible that if these cases were carefully investigated it would be found that these cases may in reality have had syphilis, possibly hereditary, and that these reactions are not actually false positives. At the worst there are only 5 out of 500, or 1 per cent, of false positives recorded in these comparative tests. While such a percentage of false positives is worthy of consideration in making the diagnosis on an individual case, it can not seriously affect the accuracy of the survey work reported in this bulletin.

From all of the foregoing facts we draw the following conclusions:

1. That antigens consisting of cholesterinized extracts of human heart do not give more false positives than any other antigens when used with the proper technique.

2. That the Wassermann reaction as it is performed in this laboratory is sufficiently exact to give trustworthy results in survey work, and that therefore the statistics presented in this bulletin may be considered reliable.

The interpretation of the readings of this Wassermann reaction must still be discussed. Such an interpretation for purposes of diagnosis has been given very fully by Capt. Craig in Bulletin No. 3, page 39, but it is necessary to discuss the value to be attached to the various readings in this survey work.

The double plus reaction.—One thousand and forty-nine cases suffering from other diseases than syphilis gave only four false positive reactions (double plus), or less than 0.4 per cent. While this possibility of error must always be taken into consideration in making the diagnosis in an individual case, in this survey work this error is too small to be of importance. We may, therefore, assume that in these surveys all men giving a double plus reaction are syphilitic.

Some may take exception to this view. Thus some authorities take the view that a positive Wassermann (double plus), in the absence of clinical symptoms of syphilis, can be ignored, since they do not believe that it indicates the existence of syphilis.

This attitude was illustrated in a case in which the Wassermann was performed in this laboratory and a double plus returned. The patient denied syphilis; was a person of excellent reputation who had been married many years and was the father of several presumably healthy children. This patient went to a well-known dermatologist in New York, who gave him a physical examination and stated that he might have a positive Wassermann but he did not have syphilis. It must be a great assistance in diagnosis to possess such omniscience. The absurdity of declaring that any individual has not syphilis on the basis of a physical examination should be apparent to anyone, since the spirochætes may and frequently do lie dormant for years, notably in the aorta, the brain, and the cord. As a matter of fact, the Wassermann was repeated on several occasions in this patient, was always double plus, and within a few years he has developed a serious heart lesion with failure of compensation, but so far as known has refused specific medication because he will not believe that he has syphilis.

The man who invariably assumes that a double plus Wassermann does not mean syphilis simply because there are at present no clinical signs of the disease, and refuses to treat the patient, is assuming a heavy burden of responsibility for the aneurisms, paresis, tabes, and other syphilitic lesions that will develop later.

It is to be understood that no claim is being made here that *every* case presenting a double plus Wassermann is to be diagnosed as syphilis and so treated. Here, as elsewhere in the practice of medicine, some judgment is necessary. The reliability of the laboratory returning the reaction should be considered. It is also to be remembered that no claims are made to-day for the specificity of the Wassermann reaction and that no one denies that there may be some substances in certain patients' sera that will give a double plus reaction aside from those resulting from a syphilitic infection. The double plus reactions that are sometimes obtained from diabetics in whose blood acidosis is present in a case in point. However, such instances are fortunately rare and are usually transitory, so that such false positives, as well as those resulting from errors in technique, as a rule can be eliminated by repeated examinations. Therefore in all such doubtful cases in which the diagnosis is to be made on the double plus Wassermann alone it is necessary to insist that the reaction should be repeated on several occasions. The serum should also be titrated in order to determine its strength. There is a great difference in double plus reactions. One-tenth of a cubic centimeter of some sera is required to give a double plus reaction, while one-thousandth of a cubic centimeter of another serum may be sufficient to give a double plus reaction. There would be little hesitation in making a diagnosis of syphilis in the latter case whether clinical symptoms of syphilis were present or not. There might be doubt in the former case. This question of the titration of double plus sera will be considered at greater length later.

Experience indicates that the great majority of all patients in whom the Wassermann reaction is persistently double plus are syphilitic, and that fewer mistakes will be made by treating all such cases for syphilis than will be made by refusing to treat all such cases because they do not happen to present clinical symptoms or manifestations that can be detected at the time the examination is made.

Still other authorities take the position that a positive Wassermann (double plus) does not necessarily mean that the patient has syphilis at present, but that he has had syphilis at some time in the past. Thus Marshall (12) says:

> It seems more probable that the biochemical changes which cause the reaction, though originally due to the action of spirochætes, may continue independently of the presence of these organisms.

Again, Marshall says (loc. cit., p. 56):

> Further, if we accept the most recent explanations of the nature of the reaction, a positive result does not necessarily show the presence of active syphilis, for according to the lipoid theory the reaction is due to tissue changes, which may persist after the spirochætes are dead. As Candler remarks, "A positive serum reaction merely indicates that the patient has had syphilis."

It is natural that clinicians who used to assert that they cured syphilis with two years of mercury should adopt such opinions, for it is the only refuge from the conclusion that few patients who had syphilis ever were cured. But this view is regarded not only as incorrect but as highly dangerous to the patient. For, admitting at once that the Wassermann reaction is not specific in any sense of the word, but is a reaction between certain lipoids and the lipotropic substances in the blood of syphilitics, it must also be admitted that, barring the very small percentage of false positive reactions, these lipotropic substances are present in the blood of syphilitics as the result of the action of spirochætes upon the tissues of the patient. The statement that "a positive Wassermann merely indicates that the patient has had syphilis" is based upon the assumption that these lipotropic substances may remain in a patient's serum for a long time after the spirochætes that produced them are dead. From the standpoint of the proper treatment of the patient, this would be a risky assumption, even if the known facts favored this assumption. The facts, however, do quite the reverse.

It has long been known that syphilis confers no lasting immunity, as shown by repeated cases of reinfection after cure. Immune bodies or lipotropic substances can not be demonstrated in the blood of patients who conform to the usual standards of cured cases. Still more important is the fact that has now been demonstrated, that the Wassermann reaction disappears from the blood from the second to the fourth week after the administration of a sufficient dosage of salvarsan in the great majority of cases. This indicates clearly that the lipotropic substances in the blood do not remain in the circulation long after the spirochætes that produced them are killed.

The apparent exceptions to this rule, who in spite of such treatment still retain a positive Wassermann, almost invariably suffer a clinical relapse if followed for a sufficient length of time. From these considerations it is apparent that the only safe rule for the patient is to assume that a positive Wassermann (double plus) indicates the presence of living spirochætes, i. e., syphilis, which may be latent clinically, but which remains capable of further development and the production of syphilitic lesions at any time favorable for the development of the organisms.

To many these remarks will appear rather platitudinous, but, as illustrated by the quotations previously given, syphilographers are by no means unanimous on this point, and its discussion is necessary to indicate the value that is to be attached to the double plus Wassermann reaction in these surveys.

We must further make the point that in counting all double plus reactions as syphilis the error is on the side of conservatism, since the figures given in Table I indicate that the Wasermann reaction is only positive (counting both double plus and plus reactions) in 84.09 per cent of cases.

The plus reaction.—Our figures show that plus reactions are returned in about 1 per cent of nonsyphilitic cases. On the other hand, the plus reaction is very commonly found in cases of undoubted syphilis. It is naturally quite common in the early stages of primary syphilis. Capt. Craig (loc. cit., p. 41) found that a plus reaction is observed in about 15 per cent of cases in the secondary stage of syphilis, even when very active symptoms are present. A still higher percentage of patients in the tertiary stage give only a plus reaction. From all of these facts it is apparent that while in an individual case a diagnosis of syphilis should never be made on a plus reaction except in the presence of a confirmatory history or clinical condition, yet in this survey work it is probable that the great majority of plus reactions returned indicate the presence of a syphilitic infection. In order to be on the safe side, however, these plus cases have never been called undoubted syphilitics. But in *estimating* the amount of syphilis probably present in a given group the plus reactions have in all cases been included. It is important, therefore, in reading the following papers to bear in mind the distinction between the statistics given for undoubted syphilis and the probable amount of syphilis.

The plus minus reaction is very common in early primary, later tertiary, and so-called latent syphilis. Since, however, about 10 per cent of diseases other than syphilis may also give a plus minus reaction, the presence of this reaction has been ignored in estimating the amount of syphilis in all groups studied.

The negative reaction.—In this survey work the negative reaction has been accepted at its face value. It is, however, universally accepted that syphilis can not be excluded on the basis of a single negative Wassermann reaction, and, as shown by Table I, about 15 per cent of known syphilitics give either a plus minus or a negative Wassermann.

The method used in estimating the amount of syphilis used in all these surveys should now be considered. The number of *undoubted syphilitics* in any group examined has been determined as follows: The number of men that have actually been diagnosed as syphilitic and have received treatment for that disease is first ascertained. Where possible, such information was obtained by securing a list of the men carried on the syphilitic registers. A Wassermann survey is then made on all the remaining men of the group. The total of all the men carried on the sick report for syphilis and all double plus reactions obtained from the Wassermann survey is used to indicate the number of undoubted syphilitics in the group studied. There can be no criticism of this use of the men carried on the syphilitic registers, for it will be admitted that men are not diagnosed, treated, and carried on the register in the service until the diagnosis is made certain. Study of the syphilitic registers on file in this office indicates that only a small percentage of these treated cases can be considered cured. This use of the cases giving a double plus Wassermann has already been fully discussed. For these reasons it is believed that the figures given in these surveys for undoubted syphilitics can be accepted as accurate.

The *estimate* of the number of *probable* syphilitics has been made in all cases by adding to the undoubted syphilitics all cases giving a plus Wassermann. It will be remembered that a plus reaction is only to be considered diagnostic of syphilis in the presence of a confirmatory history or of undoubted physical signs of syphilis. As a matter of fact, however, it has been found from an experience of several thousand cases, in which the reaction has been checked by the history, that the great majority of cases giving a plus reaction will on careful examination be found to present either a history or physical signs indicating syphilis. In other words, the majority of plus reactions are obtained from syphilitics. While, therefore, in the individual case we would not be justified in making a diagnosis of syphilis on a plus reaction alone, yet we are justified in *estimating* that these plus cases are probably syphilitic in this survey work.

For, although all of these cases are certainly not syphilitic, it is obvious that many cases of syphilis are missed because they have given a plus minus or negative reaction. Considering this fact, it is believed that it would not exceed the truth if all cases giving either a double plus or a plus reaction were counted as undoubted syphilitics in this survey work. It is certainly within safe limits when these plus cases are only *estimated* as *probable* syphilitics. In some of the following studies where the more or less complete clinical histories of the men examined have been available comparison is made between this method of estimating the percentage of syphilis and the percentage obtained when the clinical history is available in addition to the Wassermann.

Attention is particularly invited to these comparisons, since in each case they indicate that an estimate made on the basis of the double plus and plus Wassermann reactions is in close accord with the facts.

In conclusion, it may be stated that no one can see the inadequacy and imperfections of this work more clearly than the writer. In order to make an accurate determination of the prevalence of syphilis, a careful clinical examination should be made of every case, and the Wassermann interpreted in the light of such findings. This, of course, was an impossible standard with the necessary limitations under which this work has been performed. As a result it is impossible to state in any of the following surveys the exact percentage of syphilitics. What has actually been done is to indicate a certain percentage that may be considered to be undoubtedly syphilitic, and to make an estimate, based on the Wassermann reaction, of the total number of syphilitics. The reader should therefore keep clearly in mind the distinction between the actual number of syphilitics detected and the estimated number of men probably syphilitic.

If any excuse is necessary for the incomplete nature of the work, it may be found in the almost insuperable difficulties of such an investigation, which practically preclude the systematic examination of any large body of the population for syphilis. This work, which includes approximately 10,000 Wassermann reactions, all made in the deliberate attempt to determine the prevalence of syphilis, may at least be said to afford a better idea of the prevalence of syphilis in the Army than any previous work. The practical importance of the subject would indicate that this work should be continued and extended as recommended in the concluding papers of this bulletin.

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Part I.

THE PREVALENCE OF SYPHILIS AMONG MEN JUST ENTERING THE SERVICE.

THE PREVALENCE OF SYPHILIS AMONG ACCEPTED RECRUITS FOR THE UNITED STATES ARMY, AS SHOWN BY A WASSERMANN SURVEY.

In any attempt to consider the prevalence and prevention of venereal diseases in the Army it is a matter of importance to know what proportion of the total number of cases have been acquired by the recruit before he leaves civil life and how many cases are acquired by the men while actually in the service. Venereal prophylaxis has now become the order of the day, and for several years the sick reports have been scrutinized to observe the effect of this measure. It is clear, however, that the number of men on sick report from venereal disease would necessarily remain high, in spite of a material reduction in the number of infections acquired during military service, if a very considerable proportion of these cases were acquired prior to enlistment.

We have never had any exact information on this point, but from time to time medical officers have expressed the opinion that much of the syphilis in the Army was contracted by the recruit prior to his enlistment. Thus Howard[1] states:

> Jefferson Barracks is one of the larger recruit depots, and has a continually changing personnel. Nearly 10,000 recruits pass through the depot during the year. A majority of admissions for venereal disease at Jefferson Barracks during the past year have been due to infections contracted prior to enlistment or before arrival at the post.

In the physical examinations to which each recruit is subjected prior to his enlistment an attempt is naturally made to exclude those suffering from venereal disease, and a considerable number of men are actually so rejected. According to the present system a young man presents himself to a recruiting officer in some city. He is given a preliminary physical examination by the recruiting officer, who rejects him if he presents obvious physical defects, including clear evidence of recent venereal disease. Having passed this examination, the candidate is sent to the nearest recruit depot, where he is subjected to a thorough physical examination by a medical officer.

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[1] Maj. Deane C. Howard, M. C. Venereal Prophylaxis in Armies. Bulletin No. 2, Surgeon General of the Army, p. 41.

We will have reason later to consider the exact amount of venereal disease excluded by these examinations, but for the present we will be satisfied with the statement that a very large number of venereal diseases are detected and eliminated by this procedure.

But both gonorrhea and syphilis, particularly the latter, are prone to become latent. If a man has no sore or scar on his penis and no physical signs of active syphilis he may easily be enlisted while suffering from this latent syphilis. Indeed, he may even be in the active secondary stage, the symptoms being temporarily obscured by treatment. The officer, who has conducted this physical examination with the greatest care, will perhaps be inclined to insist that while, of course, an occasional case of syphilis may "get by" him, yet the total number of such cases can not be large. On the other hand is the experience of numerous other officers, who, like Maj. Howard, have found that a large part of the syphilis in the Army is contracted prior to enlistment.

The present study was undertaken to obtain information on this very important point. This survey is also interesting in that it affords evidence as to the amount of syphilis among this class of men in civil life. While the men here surveyed are accepted recruits, they differ in no respect from other young men in this walk of life except that they have already passed two physical examinations, in the course of which a certain amount of venereal disease has been eliminated.

In order to avoid including cases of syphilis contracted after enlistment, no men were taken for this examination who had been enlisted more than a week; this also excluded all reenlistments. Any attempt to select cases was avoided by taking all accepted recruits just as they came. Since it might be supposed that the percentage of syphilis would vary in different parts of the country, two series of men were taken from two different recruit depots. The first of these, Fort Slocum, is situated near New York, and receives chiefly those recruits obtained from New York City and vicinity. The second, Columbus Barracks, is located at Columbus, Ohio, and the men sent here come largely from the country and small towns in the Middle West and South.

The surgeons in charge of these depots were directed by the Surgeon General to take blood specimens from every man accepted and enlisted less than a week until 500 had been taken. The bloods were collected in Wright capsules in accordance with the technique used in the Army to collect blood for the Wassermann reaction, and these specimens were at once mailed to the Army Medical School, Washington, D. C. The Wassermann was performed in all cases on the day following the receipt of the specimens. The specimens were, therefore, in no case more than a day in transit and almost all were received in good condition. The few that were spoiled in transit were thrown out, and fresh suitable specimens were obtained.

The results of the Wassermann reaction on these men may be seen in the following table:

From this it will be seen that 79 men, or 7.75 per cent of the total number of recruits examined, give a double-plus reaction. In accordance with the method discussed in the introduction, these men are classed as undoubted syphilitics. It is, of course, obvious that there are none among this group diagnosed as syphilis.

Ninety-two, or 9.02 per cent of the total number examined, gave a plus reaction. These cases when added to the double-plus reactions afford the estimate of probable syphilitics as indicated in Table II.

TABLE II.

Place.	Total examined.	+ +		+		+ −		−	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Fort Slocum	500	35	7.00	48	9.60	54	10.80	363	72.60
Columbus Barracks	519	44	8.48	44	8.48	52	10.01	379	73.02
Total	1,019	79	7.75	92	9.02	106	10.40	742	72.81

Place.	Number examined.	Known syphilitics.	+ + Wasserman.		Total undoubted syphilitics.		+ Wasserman.		Estimated probable syphilitics.	
			Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Fort Slocum	500	0	35	7.00	35	7.00	48	9.60	83	16.60
Columbus Barracks	519	0	44	8.48	44	8.48	44	8.48	88	16.96
Total	1,019	0	79	7.75	79	7.75	92	9.02	171	16.77

A noteworthy point brought out by these tables is the fact that there is so little variation in the results from two such widely separated points as Fort Slocum and Columbus Barracks. In the former case recruits are largely secured from New York and the vicinity, while in the latter case recruits are largely obtained from the country. It may possibly be deduced from this that the prevalence of syphilis does not vary greatly in different parts of the country, although, of course, it varies considerably in the different classes of society. If this is true, it is most important, since it indicates that the figures obtained in this survey may be considered to be approximately correct for other parts of the country, and therefore that deductions based on these figures are generally applicable.

Since many may think these figures too high, it will be well to make a comparison at this point. By turning to the survey on the inmates of the Soldiers' Home it will be seen that by adding the double plus and plus Wassermann reactions we found 22.1 per cent to be syphilitic. Now, when the Wassermann reaction was considered in connection with the clinical history and only the plus cases in which confirmatory evidence was found were considered syphilitic but the negative and plus minus cases giving a clear history of syphilis were added we found that 25 per cent were syphilitic.

It is clear, therefore, that we do not exaggerate the amount of syphilis among these recruits when we estimate probable syphilitics on the basis of the total double plus and plus reactions. On the contrary, this estimate is probably too low, since in this case it has been impossible to add any known syphilitics to these figures.

However, estimated in accordance with Table II, we have found 16.77 per cent of the 1,019 accepted recruits to be probably syphilitic. This is a truly astonishing state of affairs. It is quite remarkable that after two physical examinations there should remain so many men with undetected syphilis. This fact alone is eloquent testimony as to the nature of the disease and affords food for thought for those medical men who think that syphilis is a skin disease, and that when there are no obvious eruptions or other gross lesions that the disease has not been present or is cured.

We have known several instances of medical men giving a certificate to the effect that a certain patient did not have syphilis after a simple physical examination. The worthlessness of such evidence in the face of the fact that 16.77 per cent of recruits examined have either a double plus (++) or plus (+) Wassermann reaction, but no symptoms of syphilis that are detected by that examination, is apparent. Of course it is easy to say that the physical examination given by the medical officers was not sufficiently careful. This criticism, however, will not hold water. The physical examination given the recruits for the Army is very thorough, and the medical officers who conduct it are, with few exceptions, skilled in the technique of physical examination to a far greater degree than most physicians. Let us concede that a few cases of syphilis are overlooked which ought to be recognized. This is only to admit the usual percentage of error to which all human performances are susceptible. Neither carelessness in the examination nor this human factor of error will account for 16 per cent of syphilitics admitted to the Army. It is clear that the bulk of these cases are unrecognizable by the present examination.

Another point to be considered is the influx of this amount of syphilis on the sick report of the Army. If 16 per cent of the recruits of the Army are syphilitic—and there is no reason to suppose that there was more syphilis among this thousand men examined than among the many thousands taken in each year—then in every post of 1,000 men there are 160 men who were already infected with syphilis at the time they entered the Army. Our sick report has been a reproach for many years, in that we have had a higher admission rate and more men constantly on sick report because of venereal diseases than any other army in the world. It is now clear that, so far as syphilis is concerned, this high percentage of cases is largely due to cases contracted by the recruits before leaving civil life and that the Army itself can no longer be held responsible for this condition. It is further apparent that, no matter how efficient the venereal prophylaxis of the Army may be, there will still remain a very large number of cases of syphilis contracted prior to enlistment until means are taken to exclude such syphilitics. Until such action is taken, we can not expect any great reduction in the statistics for syphilis, and it follows that the failure to obtain such a reduction can not be used as an argument to indicate the uselessness of the methods used in venereal prophylaxis.

If we wish to improve our rates for syphilis, some method must be devised for excluding syphilitic recruits. This is a subject requiring special consideration, and is briefly treated in a subsequent part of this bulletin.

Let us now consider the bearing of these figures on the prevalence of syphilis among the young men of the civilian community.

The age of these recruits.—609.67 per thousand of all recruits accepted during the fiscal year 1913 were 24 years of age or under, and the ages 21 and 22 furnished the largest number for any age in the order named. The following table shows the ages of recruits and the proportion at each age per 1,000 accepted during the fiscal year 1913:

Ages.	White.		Ages.	White.	
	Number.	Ratio.		Number.	Ratio.
18 years and under	1,989	76.64	31 years	577	22.23
19 years	1,148	44.24	32 years	558	21.50
20 years	600	23.12	33 years	449	17.30
21 years	6,118	235.74	34 years	356	13.72
22 years	2,555	98.45	35 years	305	11.75
23 years	1,604	61.81	36 years	297	11.44
24 years	1,808	69.67	37 years	234	9.02
25 years	1,421	54.76	38 years	176	6.78
26 years	1,123	43.27	39 years	172	6.63
27 years	1,072	41.31	40 years and over	1,100	42.39
28 years	896	34.53			
29 years	766	29.52	Total	25,952	1,000.00
30 years	628	24.20			

It must be remembered that this table includes reenlistments. The enlistments made of men of 30 and over are almost all reenlistments. The men enlisted for the first time are, therefore, between the ages of 18 and 30, and the vast majority between the ages of 21 and 24.

The social class to which these recruits belong is well indicated by their occupations. The Surgeon General's Report for 1913, page 207, indicates these occupations in the following table:

Principal occupations of white recruits, first enlistment, year 1912.

Occupation.	White.	Occupation.	White.
Laborers	4,509	Conductors	29
Farmers	2,633	Leather workers	28
Clerks	959	Cigar makers	27
Drivers and stablemen	839	Core makers	26
Machinists	615	Draftsmen	26
Miners	498	Furniture workers	26
Cooks	319	Civil engineers	23
Carpenters	386	Merchants	22
Firemen	358	Cement workers	18
Painters	348	Bridge workers	18
Electricians	270	Photographers	17
Plumbers	243	Foremen	16
Musicians	229	Packers	14
Printers	224	Confectioners	16
Waiters	147	Actors	15
Barbers	188	Gardeners	16
Railroad hands	182	Undertakers	14
Tailors	161	Box makers	15
Butchers	155	Drillers	12
Salesmen	160	Hatters	13
Porters	49	Laundrymen	10
Chauffeurs	133	Coopers	12
Metal workers	149	Journalists	10
Bakers	141	Bartenders	10
Blacksmiths	113	Rubber workers	11
Shoemakers	121	Dairymen	11
Bookkeepers	111	Doctors	9
Telegraphers	112	Trimmers	11
Sailors	94	Florists	10
Weavers	97	Lithographers	10
Engineers	93	Oilers	10
Linemen	82	Roofers	10
Masons (brick and stone)	73	Inspectors	9
Molders	62	Agents	7
Mill workers	74	Chemists	8
Tinners	70	Collectors	8
Mechanics	92	Automobile workers	7
Students	59	Bottlers	6
Boilermakers	56	Brewers	6
Horseshoers	49	Potters	6
Teachers	46	Dyers	7
Motormen	48	Designers and decorators	6
Druggists	43	Fishermen	4
Nurses	45	Ball players	6
Glassworkers	42	Dentists	6
Lumbermen	40	Moving-picture operators	6
Jewelers	35	Upholsterers	6
Stenographers	33	Miscellaneous	128
Plasterers	27		
Paper workers	29	Total	16,382

It must be remembered that these accepted recruits of this age and occupation are picked men, and 16.77 per cent were probably syphilitic. Is it possible to form any estimate as to what is the percentage of syphilis among the men of the community from whom these recruits were picked? It is impossible to give any exact figures on this point. The Adjutant General's Report for 1913 says (p. 32):

> It will be seen from the foregoing table that 80 per cent of the applicants for enlistment at recruiting stations were rejected at those stations, and also that 14 per cent of those accepted at stations were subsequently rejected at depots.

We have no information as to what percentage of the rejections at the recruiting stations were due to venereal diseases, but undoubtedly there was a certain percentage of rejections for this cause.

When, however, we come to consider the additional 1½ per cent rejected at the recruit depots, we find accurate statistics as to the cause of rejection on page 206 of the Surgeon General's Report for 1913. Venereal diseases are found to cause the largest proportion of rejections, the rate being 97.73 per thousand in 1912 and 111.67 in 1911. In the white race, venereal diseases caused the second highest number of rejections, being 92.39 per 1,000 in 1912. In the colored race the rate of rejections per thousand for venereal diseases was 167.86. This was, moreover, decidedly lower than the rate obtaining in 1911, when 221.65 per 1,000 colored applicants were rejected for venereal disease. There are unfortunately no figures to show what proportion of these rejections for venereal disease were due to syphilis.

With regard to the white race, which alone is considered in this study, we have seen that 92.39 per 1,000, or 9.2 per cent of the rejections at the recruit depot, were rejected for venereal disease. Assuming, as has been done frequently, that gonorrhea is about four times as common as syphilis, we find that 2.3 per cent of the total number of these rejections were due to syphilis.

If we assume, and the assumption is probably conservative, that there was the same proportion of syphilis among the 80 per cent of rejections at the recruiting stations, the total 83 per cent of rejected men must have had approximately 2.3 per cent of their number rejected for syphilis.

It seems evident that since the two physical examinations to which these applicants for enlistment were subjected resulted in the rejection of approximately 83 per cent, that there must have been more syphilis among the 83 per cent rejected than among the 17 per cent accepted. We have, however, demonstrated that of this 17 per cent of accepted recruits, 16.77 per cent are probably syphilitic.

Therefore, it seems fair to estimate that the percentage of syphilis among the men originally presenting themselves to the recruiting officer is the same as the percentage found by the Wassermann survey on accepted recruits plus the estimated 2.3 per cent of rejections for syphilis. This makes a total of 19.07 per cent of syphilis for all applicants for enlistment, or about one out of every five applicants.

We may, therefore, conclude that among the young men in civil life between the ages of 20 and 30, and of the general class belonging to the occupations mentioned, the percentage of syphilis may be estimated at at least 16.77 per cent, and there is good reason for believing that it is fully 20 per cent.

This estimate does not differ essentially from one recently made by Dr. Charles G. Banks,[1] although as the result of his investigation Dr. Banks draws the conclusion that the prevalence of venereal diseases is much overestimated. This conclusion appears to rest on the fallacy that the number of venereal diseases actually treated in hospitals is equivalent to their prevalence, and is drawn in spite of the fact that even this inconclusive data leads to the estimate that 2 per cent of the male population becomes syphilized annually.

Thus, Dr. Banks bases his estimate on the number of sailors actually diagnosed and treated for syphilis or gonorrhea in all the marine hospitals over a series of years. He found the percentage of annual venereal infection among mariners to be 8.15, and assumes from the nature of such men that the average jack tar is more likely to suffer from venereal disease than the average civilian, and that it is therefore fair to say that not more than 5 per cent of adult males can be properly under suspicion as annual venereal victims. Of these males, in round numbers, 2 per cent would be syphilized.

It may be objected to this method of estimation that it is far below the actual facts, since it can not be supposed for an instant that all the sailors having a venereal infection have brought it to the marine hospital.

Many cases of syphilis are undoubtedly contracted shortly before sailing, develop on shipboard, become more or less latent, and some are never diagnosed or receive treatment at any hospital, while many other cases are doubtless self-treated or treated at other hospitals and dispensaries. As we will see later, statistics for the enlisted men of the Army indicate that about 3.44 per cent are annually diagnosed and treated for syphilis. But the Wassermann survey of these soldiers shows an additional 4.77 per cent of double plus reactions and 7.87 per cent plus reactions, so that the total estimated syphilitics for these men is 16.08 per cent. Were the Wassermann reaction to be applied to the sailors on whom Dr. Banks bases his statistics, similar results might be expected. In other words, probably at least 20 per cent of these sailors were syphilized at any one time.

It may be admitted that although syphilis may be cured, as a matter of fact, as treatment is generally given it is rarely cured. If 2 per cent are infected annually these cases remain infected, and therefore there is a steady accumulation of cases. Of course the percentage of syphilitics in the community must become reduced by the new additions of clean humanity, or otherwise the entire community would become syphilized in 50 years if there were an annual increment of 2 per cent. But it is impossible to guess to what extent these fresh additions reduce the percentage. We do know that this process has been going on for many years, and if there are 2 per cent of fresh infections of syphilis annually the estimate that 20 per cent of the adult males of the population are syphilized does not appear at all excessive. But contrary to Dr. Banks's conclusion it does seem exceedingly startling. It means that when a man's daughter marries, the chances are just 1 to 5 that she will become the victim of "damaged goods." Further discussion of this point is out of place in this bulletin, but it may be stated that the writer hopes to extend these observations to the civilian community in the future.

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[1] Banks. Venereal Disease: Its Probable Prevalence. Public Health Reports, Feb. 26, 1915, Vol. XXX, p. 618.

THE PREVALENCE OF SYPHILIS AMONG THE CADETS AT THE UNITED STATES MILITARY ACADEMY AT WEST POINT.

An investigation of the prevalence of syphilis among the cadets at West Point should be of practical interest and importance to the Army, and should also be a matter of some general interest. So far as the Army is concerned this interest arises from the fact that practically all of these cadets eventually enter the Army as commissioned officers, and that therefore the amount of syphilis among cadets will afford a very definite clue to the per cent of syphilis already acquired by officers of the Army at the time they are commissioned; or in other words the percentage of syphilis that is being admitted to the commissioned personnel from civil life.

The consideration that should be of general interest arises from the fact that these cadets are a very special class of young men. They come from all over the country, from families whose financial circumstances are either moderate or well to do, as a general rule; they have all received a thorough preliminary education at least equivalent to that obtained in the usual high school. They are all young men of presumably excellent moral character, and all have passed a rigid physical examination prior to their entrance to West Point. Surely it might be expected that among a group of such young men so carefully selected there would be little syphilis.

This investigation has been carried out in the same manner as the studies made on enlisted men. The surgeon at West Point was requested to inform me of the number of cadets known to have syphilis, and a blood specimen for the Wassermann reaction was collected from every man in the Cadet Corps and forwarded to the Army Medical School, where the reaction was performed.

I am indebted to Lieut. Col. Henry A. Shaw, the surgeon at West Point, for the pains taken to collect these specimens satisfactorily.

The results of this Wassermann survey are shown in Table I.

TABLE I.—*Wassermann survey of cadets.*

Number examined.	+ +		+		+ −		−	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
621	16	2.57	18	2.89	30	4.83	557	89.69

The age of the cadets examined is shown in Table II. It has been impossible to estimate the incidence of syphilis for various ages, because the number of cases of syphilis is so small.

TABLE II.—*Age of cadets examined.*

Age (years)	17	18	19	20	21	22	23	24	25	26	27	Total,
Number	1	40	67	106	123	124	79	48	30	2	1	621

I was informed by Col. Shaw that there were no known syphilitics among these cadets. In accordance with the method used in other surveys, it may be estimated that 2.57 per cent of the cadets are syphilitic and that 2.89 per cent more are probably syphilitic, a total of 5.46 per cent estimated syphilitics. It is evident that this figure is much lower than the results obtained for recruits, in which case 7.75 per cent of double plus reactions and 9.02 per cent of plus reactions were obtained, or a total of 16.77 per cent estimated syphilitics. This is what might be expected, since the percentage of syphilis among the class of young men admitted to West Point would naturally be supposed to be lower than the percentage among the class of young men who enlist. It shows, however, that from 2 to 5 per cent of these cadets are probably syphilitic.

It is improbable that syphilis is contracted very often during the period of service at West Point. That this is possible and does occur occasionally is certain, because in several such cases blood specimens have been sent to this laboratory, but such cases are exceptional. Such syphilis as occurs among the cadets is, therefore, generally contracted prior to their entrance to the academy. A case has recently been referred to the Surgeon General, in which a history of syphilis was admitted, for decision as to the possibility of entering West Point. For every case that volunteers a history in this way it is probable that there are many other cases in which this history is concealed.

It may be assumed that the percentage of syphilis is no lower among candidates for a commission from civil life, while it is undoubtedly higher among enlisted candidates for a commission. If this is true, from 2 to 5 per cent of the commissioned personnel of the Army are syphilitic at the time they enter the service. There is at present no means of estimating the percentage of syphilis among commissioned officers, but it may be assumed that a certain further percentage is acquired during military service. The percentage of syphilis so acquired is, however, undoubtedly smaller than is the case among officers of foreign services, owing to the fact that so large a proportion of the officers of the United States Army are married.

It is clearly highly desirable to exclude syphilitics from the commissioned personnel as far as possible, and it therefore appears that a Wassermann test should be made as a regular part of the physical examination of all applicants for admission to West Point and also of all candidates for a commission, including the cadets shortly before their graduation.

So far as the bearing of these results on statistics among civilians is concerned, it may be said that, since these infections in cadets were practically all acquired prior to entrance to the academy and, since applicants to West Point are subjected to a very careful physical examination, whereas there is no physical examination for students entering college, it appears probable that the prevalence of syphilis among the young men entering any of our colleges is certainly no less and probably slightly higher than the statistics just given for West Point.

PART II.

THE PREVALENCE OF SYPHILIS AMONG SOLDIERS OF THE UNITED STATES ARMY.

THE PREVALENCE OF SYPHILIS AMONG WHITE ENLISTED MEN.

The annual reports of the Surgeon General of the Army contain an accurate record of the number of cases of syphilis actually diagnosed and treated. In the report for 1913, page 60, is a table showing the venereal diseases of enlisted men, by years, from 1908–1912. The following table presents this data with regard to syphilis alone:

Syphilis, by years, 1908–1912, United States, excluding Alaska, enlisted men.[1]

Year.	Number of cases after deducting recurrent admissions.	Admitted.		
		Total.	White.	Colored.
1912	25.58	25.58	25.84	19.69
1911	36.37	44.30	45.33	25.91
1910	22.54	26.65	26.68	26.12
1909	22.01	26.85	26.47	37.74
1908	19.99	23.15	22.46	66.30

[1] Ratio per 1,000 of mean strength.

It will be seen from this table that in 1911 there was a considerable increase in the number of recorded cases over 1909 and 1910, amounting to about 14 per 1,000 men. This increase in the number of recorded cases in 1911, however, does not indicate that there was more actual syphilis during that year than in other years for the following reasons: There was probably no increase in exposure to syphilis in that year, because the rate for gonorrhea dropped 10 per 1,000 during the same year. But the use of the Wassermann reaction as a diagnostic measure became general in 1911, and it was also during this same year that salvarsan was introduced. The Wassermann reaction detected many cases that would otherwise have remained unknown, and many other cases applied voluntarily for treatment in the hope of a permanent cure. It is probable, therefore, that there was no real increase in the amount of syphilis in the year 1911, but merely that there was less concealed syphilis. The figures for 1911 (36.37 per 1,000, or 3.6 per cent) are a better index of the amount of syphilis among the enlisted men of the Army than are the figures for any other year. Some have even been inclined to believe that the application of the Wassermann reaction and the greatly increased interest in syphilis on the part of medical officers following the brilliant results obtained by the use of salvarsan have brought practically all of the syphilis of the Army on record.

This impression, however, is undoubtedly erroneous, for we have further evidence that there is more than 3.6 per cent of syphilis among the enlisted men from various other sources. Chief among these is the Wassermann survey made by Reasoner and Matson (Military Surgeon, 1910, XXVII, 182). These investigators examined a total of 950 enlisted men at Vancouver Barracks, Washington State, and came to the following conclusion:

> We have examined in all 950 individuals, which makes over 1,000 reactions, since repeated reactions were made in a number of cases. Of these we have found 38 positive who gave a history and 12 who do not admit infection. Eight from whom histories were obtained gave negative reactions. Of the 38 positives who admit a history, 19 date back from 2 to 10 years, and it is believed that some of the 12 not giving histories should also be included if the truth were known. This makes about 5 per cent of the enlisted personnel who gave evidence of syphilic lesions, and with that a large number are recruits.

After the publication of this article this work was continued by Capt. Reasoner, who informs me that the Wassermann reaction was performed on 1,371 cases, of whom 94, or 6.85 per cent, gave a double plus reaction. Several antigens were used in this work, but cholesterinized antigens had not yet been introduced. On the basis of this evidence Capt. Reasoner believed that 7 per cent of syphilitics was a conservative estimate for that command, which consisted during this investigation of two regiments of Infantry that had been filled up recently with recruits.

In another regiment Capt. Bartlett made a careful study covering more than a year, and found about 10 per cent of the command infected. Although it is, of course, apparent that the percentage may vary in different commands in various parts of the country, it seems clear that the 3.6 per cent for the Army in the United States (1911) gives no adequate idea of the amount of syphilis in the Army. This point receives much further emphasis from a consideration of the Wassermann survey made on recruits just entering the service, of whom 7.75 per cent gave a double plus reaction and 9.02 per cent a plus reaction. Since there is obviously more syphilis in the Army than is shown on the records, it becomes a matter of the greatest importance to determine, so far as may be, the actual prevalence of the disease. An attempt to do so was made as follows: Three posts were selected for investigation. These posts were Fort Ethan Allen, in Vermont, a regimental Cavalry post; Plattsburg Barracks, in New York, a regimental Infantry post; and Fort McKinley, Me., a Coast Artillery post. These posts were considered to be most suitable for this work, because they represented all branches of the service, because they were sufficiently large to afford a considerable number of men, and because conditions were suitable in these posts for taking good blood specimens. Moreover, it was thought that in posts situated in or near a large city the percentage of syphilis might be higher than in the Army, as a whole, because of the greater opportunities for acquiring the disease in cities. None of the posts selected are near large cities.

In order to determine the prevalence of syphilis in these posts the following method was pursued:

1. A list was furnished of all men in the post positively known to have syphilis, as shown by the syphilitic registers. These men were accepted as known syphilitics, and no bloods were taken from these men. Repeated Wassermann examinations had, of course, been made on the great majority of these men in the ordinary routine course of diagnosis and treatment.

2. It was directed that blood specimens of all other men in the post be collected and sent in for a Wassermann survey.

The entire examination in all of these posts was completed in about three weeks from the time it was commenced. All of the enlisted men in the post at the time the examination was made were taken without selection other than the exclusion of known syphilitics noted above. It was not possible to examine the entire command in Forts Ethan Allen and Plattsburg Barracks, owing to the fact that in each case a portion of the command was absent on maneuvers when the examination was made. The blood specimens were collected under the supervision of medical officers, were shipped by mail, and were tested after at most three days after collection. In this connection I wish to express my acknowledgments to Capt. Samuel M. De Loffre, Capt. William K. Bartlett, and Capt. Floyd Kramer, Medical Corps, for their hearty cooperation and assistance in the collection of this large number of blood specimens.

The results of this examination are summarized in the following tables:

TABLE I.—*Known syphilitics.*

Post.	Total number of enlisted men in the command.	Known syphilitics.	Per cent known syphilitics.
Fort Ethan Allen	1,075	35	3.25
Plattsburg Barracks	913	34	3.72
Fort McKinley, Me.	655	22	3.35
Total	2,643	91	3.44

TABLE II.—*Results of Wassermann survey.*

Post.	Total examined.	+ +		+		+ −		−	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Fort Ethan Allen	589	29	4.92	38	6.45	46	7.81	476	80.81
Plattsburg Barracks	454	25	5.50	32	7.05	39	8.59	358	78.85
Fort McKinley, Me	534	21	3.91	54	10.11	59	11.05	400	74.90
Total	1,577	75	4.74	124	7.86	144	9.13	1,234	78.25

TABLE III.—*Undoubted syphilitics in the enlisted men studied expressed in per cent.*

Post.	Known syphilitics.	Per cent ++ by the Wassermann.	Total undoubted syphilis.
Fort Ethan Allen	3.25	4.92	8.17
Plattsburg Barracks	3.72	5.50	9.22
Fort McKinley, Me	3.35	3.91	7.26
Average per cent for the Army	3.44	4.77	8.21

TABLE IV.—*Estimated number of syphilitics in the enlisted men expressed in per cent.*

Post.	Known syphilitics.	Per cent ++ by the Wassermann.	Per cent + by the Wassermann.	Total estimated syphilitics.
Fort Ethan Allen	3.25	4.92	6.45	14.62
Plattsburg Barracks	3.72	5.50	7.05	16.27
Fort McKinley, Me	3.35	3.91	10.11	17.37
Average per cent for the Army	3.44	4.77	7.87	16.08

As in the case of the survey on recruits, there is substantial agreement in the figures obtained from different posts in widely separated parts of the country. This suggests strongly that the prevalence of syphilis is about the same in most of our posts.

It is believed that this estimate of 16 per cent of syphilis for the Army as a whole in the United States is conservative. While it is probable that the plus reactions do not in all cases indicate the existence of syphilis, experience has shown that most of them do, and that, on the other hand, many undoubted cases of syphilis give a negative or plus minus Wassermann. This undoubtedly more than counterbalances the few plus cases obtained in nonsyphilitics. It should also be remembered that, as shown by the annual reports of the Surgeon General, the incidence of syphilis is considerably higher in the Army in the Philippines and in Hawaii than in the Army in the United States.

The age and length of service in the Army was obtained in the cases of all the men examined, and the following table shows the incidence of syphilis for the different years of age:

TABLE V.

Age.	Number examined.	Number positive.	Per cent positive.	Age.	Number examined.	Number positive.	Per cent positive.
18	25	1	4.00	30	50	13	26.00
19	64	2	3.12	31	49	11	22.45
20	86	7	8.14	32	35	8	22.85
21	133	20	15.03	33	24	4	16.66
22	204	23	11.27	34	32	9	28.12
23	205	32	15.61	35	32	10	31.25
24	152	19	12.50	36	27	7	25.93
25	108	13	12.03	37	17	2	11.76
26	93	21	22.58	38	19	2	10.52
27	69	19	27.55	39	18	9	50.00
28	68	14	20.59	40 and over	74	21	28.37
29	57	8	14.03				

It is apparent that the percentage of syphilis for the different ages shows considerable variation owing to the fact that the groups considered for each age are too small. But even allowing for these variations, it is clear that there is a decided tendency for the percentage of syphilis to increase with advancing years. This fact is brought out more clearly if we consider the average percentage of syphilis for each quinquennium, as follows:

TABLE VI.—*Average per cent of syphilis for five-year periods.*

18–22	10.35
23–27	16.58
28–32	20.85
33–37	24.22
37–41	[1] 28.82

This steady increase in the percentage of syphilis with advancing years is exactly what might be expected, for syphilis, when once acquired, is very seldom cured, and the older the man the more have been his opportunities for exposure and contracting the disease. This fact must, therefore, be remembered in any attempt to estimate the amount of syphilis in a community, for if only young people are examined, the percentages so obtained will undoubtedly be too low for the community as a whole.

It is also desirable to know how the percentage of syphilis is affected by length of service in the Army. This is shown by Table VII.

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[1] The group 37–41 years contains those men who were over 41; the number over 41 is not large in comparison with the entire group, but undoubtedly assists somewhat in increasing the percentage of syphilis for this quinquennium.

TABLE VII.

Service.	Number of men examined.	Number positive.	Per cent positive.	Number negative.	Per cent negative.
Under 1 year	268	25	9.32	243	90.67
1 to 2 years	292	37	12.67	255	87.33
2 to 3 years	385	57	14.80	328	85.19
3 to 4 years	94	21	22.34	73	77.65
4 to 5 years	46	11	23.91	35	76.08
5 to 10 years	363	69	19.01	294	80.99
Over 10 years	189	56	29.63	133	70.37

This table shows clearly that there is a gradual and steadily increasing amount of syphilis as the years of service increase. The only exception to this rule is found in the group having between 5 and 10 years' service, in which there is apparently some decrease in the amount of syphilis. The reason for this is possibly that the groups from 3 to 4 years and from 4 to 5 years are quite small, and may show a relatively greater percentage of syphilis than would have been the case had larger groups been available.

It should be noticed that over 9 per cent of syphilis is found in men having less than one year of service. The great majority of these cases were undoubtedly acquired prior to entering the service. This is also true of a great many of the cases found in the men in the second and third years of service. These observations, therefore, confirm the results of the Wassermann survey made on recruits, in which it was found that of recruits entering the service at least 7.75 per cent are syphilitic and probably 16.77 per cent are syphilitic.

A certain amount of syphilis is, of course, acquired during service in the Army, as would be shown by these figures if we were not already familiar with the fact. But there is no reason for supposing that those men who serve in the Army are any more liable to syphilis than other men of the same age who remain in civil life. On the contrary, there are many reasons, which will be discussed later, that lead us to believe that the men who stay in the Army show a lower percentage of syphilis than men of the same age and condition in civil life. One very good reason for this belief is as follows: 7.75 per cent of the recruits are certainly syphilitic (double plus Wassermann) and 9 per cent more are probably syphilitic (plus Wassermann). These are men selected by a careful physical examination, and therefore undoubtedly suffer from less syphilis than the group of men from which they were drawn. It is fair to estimate, therefore, that there is probably 20 per cent of syphilis among the young men of the community of the class from whom our recruits are drawn.

But a similar examination of the Army shows that there are only 8.21 per cent of undoubted syphilitics and only 16.08 per cent of estimated syphilis among the soldiers, and this in spite of the fact that it was possible to obtain considerably more information (histories of known syphilitics) in the case of the soldiers. This shows conclusively that there is less syphilis in the Army than among men of the same age and condition in civil life at the beginning of their period of service. After entering the Army they are subjected to military discipline and compelled to take the prophylactic treatment after exposure, so that it seems certain that they contract less syphilis while in the service than do their confreres outside the service, few of whom have ever heard of prophylaxis.

It is also clear that, if these figures are correct, there is certainly no more syphilis among the enlisted men of the Army than is to be found among the recruits, and this in spite of the fact that a considerable amount of syphilis is undoubtedly contracted by these men during their period of service in the Army. If our figures are reliable, it is clear that the only possible explanation of this phenomenon is that syphilitics are leaving the service faster than new cases of syphilis are being acquired, and this is probably the fact.

The discussion of this point, and the endeavor to determine in what way syphilitics become separated from the service, may be deferred advantageously until the surveys on men that have recently left the service have been presented.

It is to be hoped that for the future the finger of scorn will no longer be pointed at our Army because of the amount of venereal disease that the soldiers acquire. This investigation indicates clearly that in this respect conditions are better in the Army than in civil life. The only reason for the contrary opinion has been based on the fact that in the Army when venereal diseases are diagnosed they are made a matter of record, while no one knows the diseases that civilians suffer from. A similar reputation for drunkenness has been built up for the Army, because when a man in uniform is drunk every one notices the fact, while he may be in the company of 10 drunken civilians who are not noticed because not in uniform. If sanitarians in civil life want to know how clean our Army is, let them make venereal diseases reportable like typhoid fever and diphtheria. If this were done, it is safe to say that the "holier than thou" attitude would no longer be assumed toward the soldier.

THE PREVALENCE OF SYPHILIS AMONG COLORED ENLISTED MEN.

Within recent years much interest has been displayed in the prevalence of syphilis among negroes in the civil community, and all the evidence obtainable indicates that this disease is considerably more frequent among negroes than among whites of a similar economic class. One of the first to call attention to this state of affairs was Murrell,[1] who wrote in 1910 that—

> Morality among these people is almost a joke, and is only assumed as a matter of convenience or when there is a lack of desire and opportunity for indulgence, and venereal diseases are well-nigh universal. It is my honest belief that another 50 years will find an unsyphilitic negro a freak unless some such procedure as vaccination comes to the relief of the race, and that in the hands of a compelling law. Tuberculosis is often spoken of as the scourge of the negro, but there must be 20 syphilitics to the 1 consumptive, and hundreds of the negro consumptives have syphilis to combat as well. This may sound exaggerated, but it is near the pitiless truth.

No criticism has been directed at Murrell for these statements, but, on the contrary, all who have written on the subject more recently have confirmed his observations and added fresh evidence to indicate their accuracy. Among these may be mentioned Hazen,[2] Hindman,[3] and Lee.[4] Lee writes:

> I have found from personal experience and I am sure that those doctors present who have had the disagreeable duty of treating a large number of the Negro race have found that venereal diseases are present in over 50 per cent of the race presenting themselves for treatment. Syphilis has as much to do with the high death rate in the negro as any other single factor. It does not show in the death certificate, but as a complication of bronchitis, pneumonia, and tuberculosis it reduces the chance of a successful fight against these diseases, and as a cause of arteriosclerosis, endocarditis, cerebral hemorrhage, nephritis, and stillbirths it seems to be ever present. As city physician during these years I treated 1,426 negroes, 486 of whom (about one-third) had syphilis in some evident form, to say nothing of those who came to me with minor injuries, etc., who only paid me one or two visits, and in whom the disease was latent, and in whom I did not make the diagnosis. I personally believe that more than 50 per cent of the colored race suffer with this disease, either inherited or acquired. If this be the case, as I believe it is, syphilis is almost the important factor in the high death rate of the Negro race.

With such evidence before us it might reasonably be expected that the incidence of syphilis would be higher among negro soldiers than among white troops. Turning to the Surgeon General's reports, we find this expectation only partly justified by the official figures. Thus, on page 60 of the Report of the Surgeon General for 1913, we find comparative figures on the admissions for syphilis for the two races during the years 1908–1912, which are shown in condensed form in Table I.

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[1] Murrell, T. W., Syphilis and the American negro. J. A. M. A., 1910, LIV, 846.

[2] Hazen, H. H., Syphilis in the American Negro. J. A. M. A., 1914, LXIII, 463.

[3] Hindman, S. S., Syphilis Among Insane Negroes. Am. Jr. Pub. Health, March, 1915, v. 218.

[4] Lee, L., The Negro as a Problem in Public Health Charity. Am. Jr. Pub. Health, March, 1915, V. 207.

TABLE I.

Year.	Admitted.		Noneffective.		Discharged on certificate of disability.	
	White.	Colored.	White.	Colored.	White.	Colored.
1912	25.84	19.69	1.68	2.11	0.61	0.80
1911	45.33	25.91	2.85	2.30	.48	1.36
1910	26.68	26.12	2.75	2.07	1.16	.67
1909	26.47	37.74	2.64	3.74	1.81	5.19
1908	22.46	66.30	2.14	3.46	1.64	0
Average for the five years	29.35	35.15	2.41	2.73	1.14	1.60

It will be seen from this table that while the averages during these five years for admissions, noneffectives, and discharges for disability for syphilis are always higher for the colored than for white, yet the differences are not so great as should be expected if the incidence of syphilis is as high among negroes as the references quoted above would indicate, and for certain years the figures are even lower for the colored than for whites.

Further, there is an impression in the minds of some medical officers that venereal diseases are more common among white than colored troops. Thus one medical officer, in writing to me on the subject, said:

> Experience based on nearly 17 years' continuous service with troops in garrison and field (5 years with colored troops) does not bear out the statement that the figures for venereal diseases are higher among colored troops. I have observed the incidence of venereal diseases among colored troops to be about one-half as compared with white troops. Thus there are at present under treatment in the post hospital 14 cases of venereal diseases. 4 colored and 10 white.

An attempt has accordingly been made to investigate the prevalence of syphilis among colored troops. This has been attended with some difficulty, from the fact that only two colored regiments are on duty in the United States, namely, the Ninth and Tenth Cavalry, and many of these men are scattered along the border in small posts and stations.

Surveys have been made of the men of these regiments stationed at Fort Huachuca, Ariz.; Naco, Ariz.; and Camp Douglas, Ariz. Blood specimens were collected and mailed to the Army Medical

School, where the Wassermann reaction was performed in accordance with the same method used in the other Wassermann surveys reported here. I am indebted to Maj. Charles E. Marrow, Medical Corps; Lieut. Royal E. Cummings, Medical Corps; Lieut. Raymond W. Bliss, Medical Corps; and Lieut. Waldemar A. Christensen, Medical Reserve Corps, for the trouble taken in collecting and forwarding these specimens. Owing to the long distance that these specimens traveled many of them were spoiled in transit, but all such specimens were thrown out and a second suitable specimen obtained, so that it is believed the reactions performed are reliable. The results obtained by this survey are shown in Table II.

TABLE II.—*Results of Wassermann survey of colored troops.*

Place.	Number examined.	++		+		+ −		−	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Huachuca	607	161	26.52	104	17.13	78	12.85	264	43.49
Naco	202	47	23.26	22	10.89	22	10.89	111	54.95
Apache	68	15	22.06	12	17.64	6	8.82	35	51.47
Douglas	579	98	16.90	55	9.48	56	9.64	370	63.90
Total	1,456	321	22.04	193	13.26	162	11.12	780	53.57

It will be observed that there is a greater variation in the results of the Wassermann survey from these different posts than has been the case in the surveys made in a similar way on recruits and white enlisted men. It is believed that this is partly due to the fact that there were few known syphilitics obtainable in these surveys.

I was informed by Maj. Marrow that owing to the vicissitudes of field service and frequent transfers the registers of these troops had been lost; that there were probably 50 men of the Tenth Cavalry stationed at Huachuca, Naco, and Apache who had received treatment for syphilis. However, since the records were lost, these men could not be counted as known syphilitics and excluded from the Wassermann survey, as was done in other investigations. The known cases of syphilis in the command determined since February 1, 1915, were 6. Blood specimens of these men were not included in the survey, but it is clear that very many cases of undoubted syphilitics were included that would have been excluded had not the registers been lost. This fact explains the high percentage of double-plus and plus reactions obtained in the Wassermann survey of the Tenth Cavalry as compared with the Ninth Cavalry, and also the variations observed among those portions of the Tenth Cavalry at different stations. For since many cases with a history of syphilis were included in the survey, it is probable that from one post there were more men that had received energetic treatment or suffered from old infections and gave a negative Wassermann than was the case in another post.

Therefore, although for the reason just given the figures for known syphilitics are much too low for both regiments, but especially for the Tenth Cavalry, an attempt is made in Table III to estimate undoubted and probable syphilitics for these two organizations in accordance with the method used in other surveys.

TABLE III.—*Estimate of undoubted and probable syphilis among colored enlisted men.*

Troops.	Number examined.	Known syphilitics.		+ + Wassermann.		Undoubted syphilitics.		+ Wassermann.		Estimated probable syphilitics.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Tenth Cavalry, Huachuca, Naco, Apache	883	6	0.67	223	25.25	229	25.92	138	15.62	367	41.54
Ninth Cavalry, Camp Douglas	589	10	1.69	98	16.63	108	18.33	55	9.33	163	27.67
Total	1,472	16	1.08	321	21.80	337	22.21	193	13.11	530	36.00

From this table it is apparent that the positive reactions obtained in the Wassermann survey were more numerous among those troops having fewer known syphilitics and vice versa. Comparison with figures obtained in the same way for white enlisted men indicates that syphilis is much more prevalent among colored than among white enlisted men. This comparison is made in Table IV.

TABLE IV.—*Comparison of figures obtained in surveys of white and colored enlisted men.*

Troops.	Number examined.	Known syphilitics.	+ + Wassermann.	Undoubted syphilitics.	+ Wassermann.	Estimated probable syphilitics.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
White	1,577	3.44	4.77	8,21	7.87	16.08
Colored	1,472	1.08	21.80	22.88	13.11	36.00

If the figures in these tables may be regarded as any indication of the real facts, we may conclude that syphilis is between two and three times more prevalent among colored enlisted men than among white enlisted men. That this estimate is no great exaggeration is indicated by the official figures as shown in the Surgeon General's reports for rejections of applicants for enlistment because of venereal disease. The ratio per thousand of such rejections for the last three years is given in Table V.

TABLE V.

Year.	White.	Colored.	Year.	White.	Colored.
1913	74.22	184.36	1911	111.67	221.65
1912	92.39	167.86			

If venereal diseases are more prevalent among negroes than whites before enlistment, there is no reason to suppose that this relative incidence is entirely reversed after enlistment. The observations of Murrell, Hazen, etc., on the prevalence of syphilis among negroes afford further confirmation of the essential accuracy of this survey on negro troops.

We have already seen that syphilis is much more prevalent among white enlisted men than is indicated by the official record of admissions to sick report. The disproportion between admissions to sick report and the actual number of cases present in the command is much more marked in the colored troops studied. Murrell, in the article quoted, further emphasized the difficulty in inducing a syphilitic negro to take treatment. Apparently most negroes think they are cured, or at least are satisfied as soon as they are free from pain and obvious skin lesions. This is the probable explanation of the fact that so few syphilitic negroes apply for treatment and are taken up on the sick report of the Army. It is certain in view of the facts presented here and of this well-known indisposition to take treatment that no accurate conclusions can be drawn as to the relative prevalence of syphilis in the two races by a comparison of hospital statistics or admissions to sick report.

The age and length of service in the Army was obtained in the case of all the men examined, and Table VI shows the incidence of syphilis for the different years of age.

TABLE VI.

Age.	Number examined.	Number positive.	Per cent positive.	Age.	Number examined.	Number positive.	Per cent positive.
18	10	3	30.00	30	48	23	47.91
19	42	14	33.33	31	33	10	30.30
20	59	18	30.50	32	26	6	23.07
21	82	20	24.39	33	15	3	20.00
22	131	37	28.24	34	49	23	46.93
23	121	40	33.05	35	31	15	48.38
24	103	41	39.80	36	37	19	51.08
25	69	28	40.57	37	30	10	33.33
26	53	19	35.85	38	30	13	43.33
27	55	18	32.72	39	27	17	62.96
28	59	23	38.98	40 and over	89	34	38.20
29	45	24	53.33				

As in the case of the similar table for white troops, there is a considerable variation in the incidence of syphilis for the different ages owing to the fact that the groups studied are too small. Yet here again there is a decided tendency for the percentage of syphilis to increase with advancing years. This is brought out more clearly if we consider the average percentage of syphilis for each quinquennium, as is done in Table VII.

TABLE VII.—*Average per cent of syphilis for five-year periods.*

	Colored.	White.		Colored.	White.
18 to 22	28.39	10.35	33 to 37	43.20	24.22
23 to 27	36.40	16.68	37 to 41[1]	43.83	28.82
28 to 32	40.75	20.85			

[1] The group 37 to 41 contains those men who were over 41.

In comparing these figures for the increase of syphilis with age it will be seen that between the years of 18 to 41 there is an increase of approximately 15 per cent for negroes and an increase of approximately 18 per cent for whites. These figures also indicate that more syphilis is acquired at an early age among negroes than among whites, since 28.39 per cent of the negroes were already syphilitic at the age period from 18 to 22, as compared with 10.35 per cent of whites at the same age.

The percentage of syphilis among negro enlisted men classified according to length of service is indicated in Table VIII.

TABLE VIII.

Service.	Number of men examined.	Number positive.	Per cent positive.
Under 1 year	259	90	34.74
1 to 2 years	237	69	29.11
2 to 3 years	187	75	40.10
3 to 4 years	68	22	32.35
4 to 5 years	33	11	33.33
5 to 10 years	178	69	38.76
Over 10 years	283	121	42.75

While this table indicates a tendency for an increase in the percentage of syphilis with an increased number of years of service, it is much more irregular than the increase shown to result with increasing age. This is partly due to the small groups obtained for certain periods of service, but is chiefly due to the fact that length of service bears no constant relation to the age of the individual. Thus there were many men who had long service, but who were quite young, because they enlisted at a very early age, and, on the other hand, there were a number of men of 30 years and over in their first enlistment.

There is nothing in this table to indicate that a disproportionate amount of syphilis is contracted during the period of service in the Army. On the contrary, a study of these tables, both for whites and negroes, indicates that age is the real factor governing the prevalence of syphilis and that service in the Army has probably little to do with the prevalence of infections, except that probably they are not so numerous in the service as they would be outside the service. As a matter of fact, 34.74 per cent of men with less than one year of service were positive by the Wassermann reaction, and if they are syphilitic it is a fair presumption that they acquired the infection before entering the service. This accords with the observation already made that many negroes acquire syphilis at a very early age, and indicates that the application of the Wassermann reaction to recruits may be even more useful to the service in the case of negroes than whites. It may be further seen that there is an increase of only 8 per cent of positives for those men having more than 10 years as compared with those having less than 1 year. All of these facts indicate that the service is in no way to be blamed for the large number of cases of syphilis among negro enlisted men. I have had an opportunity to examine 598 negroes in civil life. Of 267 male patients in the Washington Asylum Hospital 39.70 per cent gave a double plus Wassermann. Of 105 female patients in the Washington Asylum Hospital 42.85 per cent gave a double plus Wassermann. Of 226 males who were in the jail for vagrancy and minor offenses 31.40 per cent gave a double plus Wassermann. To be sure these were a rather poor class of negroes and inferior in every respect to our enlisted men. But the fact that the incidence of syphilis among this class of negroes in civil life is so very high is an additional indication that so far as the high figures for the colored enlisted men are concerned we are dealing with a radical question with which the Army life per se has nothing to do.

THE PREVALENCE OF SYPHILIS AMONG THE ENLISTED MEN OF THE PORTO RICO REGIMENT OF INFANTRY.

The enlisted personnel of the Porto Rico regiment of Infantry consists practically exclusively of native Porto Ricans. It was thought that a study of the prevalence of syphilis in this group would prove interesting, not only in itself but as a comparison with the surveys on other enlisted men in the United States. This study was accordingly undertaken, with the cooperation of Maj. B. H. Dutcher, Medical Corps, the surgeon on duty with the regiment at San Juan, P. R.

The first few specimens of blood sent in were so bad that some doubt was entertained as to the possibility of performing Wassermann reactions on specimens sent from this distance. However, a method was arrived at whereby only serum was sent. As a result, it has been found that excellent specimens can be secured from points as far away as Porto Rico, providing sterile serum alone is sent. The success of the work is due to the interest that Maj. Dutcher and Lieut. Arturo Carbonell, Medical Reserve Corps, have taken in it, for they took all the specimens personally, with the result that the specimens when received at this laboratory were in much better condition than is frequently the case with specimens from a short distance that have been collected less carefully.

The survey was based upon a single Wassermann reaction in each case, except that in 20 cases the reaction was repeated for various reasons.

Practically all enlisted men in the command were included, with the exception of those absent on detached service. Seven Americans (2++, 1+, 4—) were included in this survey. All others are native Porto Ricans. The results of this Wassermann survey are shown in Table I.

TABLE I.—*Results of Wasserman survey of 531 enlisted men of Porto Rico regiment of Infaury.*

Number examined.	+ +		+		+ −		−	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
531	199	37.48	82	15.44	51	9.60	199	37.48

Maj. Dutcher also investigated the sick reports of these men and furnished me with a record of all diagnoses obtainable in which the cause of admission might have some bearing on the venereal history. Maj. Dutcher states:

> The data in regard to entries on sick report are as accurate as they can be made, I think. I am personally responsible for all diagnoses after August 29, 1913. That is not to say that they are correct after that date, but they have been made as carefully as possible, taking all the attendant circumstances into consideration. I have put down for all the men every diagnosis that I thought might bear in any way on a treponematous infection. The exact phraseology of the card has not always been followed, but the lesion has been put down with abbreviations that you will understand. A few men, not over five at the outside, had diagnoses that should have gone down, but I was not able to positively identify the names. In all cases where entries are made you can rely on their accuracy, so far as transcription from our records are concerned.

I have tried to use an equal amount of care in tabulating this data. An endeavor is made in Table II to indicate the relation of the Wassermann to the history of each man. In this table the ++, +, +−, and − cases are successively analyzed. Since it would be impossible to present each case under its exact diagnosis, certain headings are used which should be described. The cases under the heading " Diagnosed as syphilis " include all cases in which the diagnosis of syphilis in any stage was actually made on the sick report. No cases are included in which the diagnosis of syphilis was not actually made, no matter how apparent the syphilitic origin of the lesion might appear.

The heading " Not so diagnosed, but having symptoms of syphilis " includes cases in which from the history alone, aside from the Wassermann reaction, a diagnosis of syphilis would appear almost certain or extremely probable. Thus all will agree that a man with a diagnosis of chancroid in May, 1910; inguinal adenitis nonsuppurative in December, 1910; acute muscular rheumatism in 1912, and orchitis in 1913 is probably syphilitic. Such a case would be included under this heading, although there is a history of a chancroid. In the same way, cases with a history of aortitis and sudden death, or sudden paralysis, general glandular enlargement, persistent leg ulcers, etc., are included under this heading.

Under the heading " No history of syphilis but history of chancroids " are included all cases in which there is no history pointing directly toward syphilis, but where there is a positive diagnosis of chancroids. This does not include all cases of chancroids, because many cases of diagnosed syphilis and those not diagnosed but with symptoms of syphilis, also had a history of having chancroids.

Under the heading " No history of syphilis or chancroids but history of gonorrhea " are included all the cases with a history of gonorrhea that had not already been classified under a previous heading. Thus a case with a history of both chancroids and gonorrhea would be classified under the former heading, because the purpose of the present table is not to include all venereal infection, but to show the relation of the history to the Wassermann reaction. The cases diagnosed as chancroidal infection are far more likely to be syphilitic in reality than are the cases diagnosed gonorrhea. Hence all cases with a double infection in this classification are included under the heading most apt to show their relation to syphilis. The total amount of venereal infection is shown in a separate table.

Under the heading "No venereal history" are included those cases having no entries on the sick report that would indicate a venereal infection. It will at once be seen that this is something vastly different from the statement that they have had no venereal history. No such statement is made, but merely that there is no record of such infection.

TABLE II.—*One hundred and ninety-nine cases having a ++ Wassermann analyzed according to their history.*

History as shown on sick report.	Number.	Per cent of ++ cases.	Per cent of total syphilis.[1]	Per cent of 531 examined.
Diagnosed as syphilis	46	23.11	20.44	8.67
Not so diagnosed, but having symptoms of syphilis	37	18.59	16.44	6.94
No record of syphilis, but history of chancroids	26	13.06	11.55	4.90
No history of syphilis or chancroids, but history of gonorrhea	13	6.53	5.77	2.45
No venereal history	77	38.69	34.22	14.50
Total	199	99.98	88.44	37.46

Eighty-two cases having a + Wassermann analyzed according to their history.

Diagnosed as syphilis	10	12.19	4.44	1.88
Not so diagnosed, but having symptoms of syphilis	14	17.07	....	2.63
No record of syphilis, but history of chancroids	14	17.07	....	2.63
No history of syphilis or chancroids, but history of gonorrhea	4	4.87	....	.75
No venereal history	40	48.78	....	7.53
Total	82	99.98	4.44	15.42

Fifty-one cases having a + — Wassermann analyzed according to their history.

Diagnosed as syphilis	2	3.92	0.88	0.37
Not so diagnosed, but having symptoms of syphilis	6	11.76	....	1.11
No record of syphilis, but history of chancroids	3	5.88	....	.56
No history of syphilis or chancroids, but history of gonorrhea	2	3.92	....	.37
No venereal history	38	74.50	....	7.15
Total	51	99.98	.88	9.56

One hundred and ninety-nine cases having a negative Wassermann analyzed according to their history.

Diagnosed as syphilis	14	7.03	6.22	2.63
Not so diagnosed, but having symptoms of syphilis	9	4.52	....	1.69
No record of syphilis, but history of chancroids	27	13.56	....	5.08
No history of syphilis or chancroids, but history of gonorrhea	45	22.61	....	8.47
No venereal history	104	52.26	....	19.58
Total	199	99.98	6.22	37.45

[1] 225 obtained from Table IV.

Several facts developed by this tabulation are worthy of further remark.

1. *The comparatively small number of syphilitic cases in which the diagnosis of syphilis was made on the sick report.*—Thus in only 23.1 per cent of the double plus cases and in 31.9 per cent of all syphilitics was the diagnosis made. The explanation of this failure to make the diagnosis is fairly apparent. Thirty-eight and six-tenths per cent of the men giving a double-plus reaction have no record of venereal disease and were detected only by the Wassermann reaction. As is the case with troops in the United States, many of these cases were probably contracted prior to enlistment and had passed their secondary period before entering the service.

Further, the Wassermann reaction has only become available for the men of this command quite recently, and all of these diagnoses were, therefore, based on the clinical history alone. Had the Wassermann been secured before making the diagnosis, many cases having suspicious lesions would have been diagnosed as syphilis. However, even with the Wassermann as it is used to-day in the service, the greater percentage of syphilis remains undiagnosed.

Bearing in mind the careful work that has been done by Maj. Dutcher, it may be assumed that diagnoses have been made in this command at least as thoroughly as in other posts in the service. The 68.1 per cent of syphilis remaining undiagnosed therefore represents about the proportion of syphilis that probably remained undiagnosed at any post in the service before the general introduction of the Wassermann reaction.

Comparing these figures with those obtained in the survey of white enlisted men in the United States, where the Wassermann reaction has been used to a greater or less extent for the past five years, we find that in the latter case there was an average of 3.44 per cent of the men examined on the sick report for syphilis, while the total amount of undoubted syphilis among these men was 8.21 per cent. That is, in the United States, with the assistance of the Wassermann reaction for diagnostic purposes, 41.86 per cent of all syphilitics were carried on the sick report and 58.14 per cent remained undiagnosed, while in Porto Rico, without the assistance of the Wassermann reaction, 31.9 per cent of all syphilitics were so diagnosed and 68.1 per cent remained undiagnosed. The difference between the percentage of total syphilitics diagnosed in the United States and Porto Rico constitutes eloquent testimony in favor of the value of the Wassermann reaction as used in the military service to-day for diagnosis. The difference between the percentage of total syphilitics diagnosed in the United States (41.86) and the percentage remaining undiagnosed (58.14) constitutes the strongest possible argument for the further extension of the use of the Wassermann reaction along the lines that will be described later.

2. *The probability that supposed chancroidal infections are in reality syphilitic.*—Textbooks and teachers of experience formerly formulated an elaborate differential diagnosis between chancroids and chancre. It has been the experience in this laboratory, gained from following the Wassermann reaction and subsequent history in a large number of venereal sores, that when the diagnosis of chancre was definitely made the subsequent events almost invariably showed this diagnosis to be correct. Quite the reverse is the case with regard to diagnoses of chancroids. In a very large percentage of such cases the subsequent history has shown conclusively that the lesion was the primary sore of syphilis. This can only mean that in many cases the primary sore of syphilis is atypical and resembles the classical picture of chancroid, or that a double infection with chancroid and syphilis frequently occurs, the chancre being masked by the appearance of the chancroid. This latter supposition is rather improbable because of the very short incubation period of chancroid and the very long incubation period of chancre. At all events it is certain that many sores apparently chancroid are in reality the primary sore of syphilis, and, therefore, any sore appearing on the genitals should be suspected of being the primary sore of syphilis. Repeated search for treponemata and repeated Wassermann reactions should be made in all such cases. These statements are emphasized by the present table, which shows that 13 per cent of all the double plus cases and 17 per cent of all the plus cases having no history of syphilis did, however, have a history of chancroidal infection. But this table does not bring out the full importance of this point for the reason that many cases diagnosed as syphilis because of secondary or tertiary symptoms actually had a history of chancroidal infection but no history of a chancre. Analysis of these cases shows that of the 106 cases having a history of chancroid 47, or 44.34 per cent, are now undoubtedly syphilitic, as shown by a positive diagnosis of syphilis or Wassermann reaction (++), although they have no history of a chancre. In addition, 14, or 13.2 per cent, of the total number of chancroidal infections have a plus Wassermann reaction (+) and are probably syphilitic.

3. The facts as to diagnosis collected by Maj. Dutcher and analyzed in this table permit a comparison to be drawn between the method used in estimating the number of undoubted and probable syphilitics in other surveys in this series, and an estimation of the number of syphilitics based on the clinical history of each case in conjunction with the Wassermann reaction, since both methods may be used in this series.

Thus in the case of the Wassermann survey on recruits, in which case no clinical data whatever were available, 7.75 per cent of double plus reactions and 9.02 per cent plus reactions were obtained. From this we concluded that 7.75 per cent of recruits were undoubtedly sphilitic and 9 per cent more were probably syphilitic.

In the case of the Porto Ricans, 37.48 per cent gave a double plus reaction and 15.44 per cent gave a plus reaction. If in a similar manner we should estimate that 37.48 per cent are undoubtedly syphilitic, and 15.44 per cent more are probably syphilitic, how much would this under or overstate the case? In order to bring out this point Table III was constructed, and from it we observe—

TABLE III.

Estimation of number of undoubted syphilitics by combined Wassermann and history on sick report.

Diagnosis made by—	Number.	Per cent of number examined.
++Wassermann	199	37.48
+Wassermann diagnosed as syphilis	10	1.88
+Wassermann symptoms of syphilis	14	2.63
+−Wassermann diagnosed as syphilis	2	.37
−Wassermann diagnosed as syphilis	14	2.63
Total	239	45.00

Estimation of number of probable syphilitics by combining Wassermann and history on sick report.

Diagnosis made by—	Number.	Per cent.
Undoubted syphilitics	239	45.00
+Cases with history of chancroids	14	2.63
+−Cases having symptoms of syphilis	6	1.11
+−Cases having history of chancroids	3	.56
−Cases having symptoms of syphilis	9	1.69
+Cases with history of gonorrhea	4	.75
Total	275	51.79

that estimated in this way 45 per cent are undoubtedly syphilitic, as compared to the estimate 37.48 per cent based on the Wassermann alone, and that the undoubted and probable syphilitics total 51.79 per cent as compared to the estimate of 52.9 per cent based on the Wassermann alone.

This would seem to indicate that our estimates of total syphilitics based on the Wassermann alone is very conservative and well within the facts, as has already been claimed.

The estimate of total undoubted and probable syphilitics based on the Wassermann reactions alone is a trifle higher than that based on the history and Wassermann combined. It must, however, be pointed out that while nearly 50 per cent of the Porto Ricans having a plus Wassermann had no venereal history whatever so far as the sick report shows, this does not by any means exclude the possibility that some of them were actually syphilitic. Thirty-eight and sixty-nine one-hundredths per cent of the men having a double plus Wassermann also had no record of a venereal infection. If any reliance whatever is to be placed on the double plus Wassermann as a diagnostic sign of syphilis, this can only indicate that many cases of syphilis are present in the service without ever having appeared on the sick report. If this is true for the double plus reactions, it may be assumed that it is also true in the case of the plus reactions, though perhaps to a lesser extent. The estimate of probable syphilitics based on the Wassermann alone exceeds the estimate based on the Wassermann as interpreted by the clinical history solely because of the large number of the plus cases without any history whatever. In view of these facts it is believed that the estimate of probable syphilitics based on the Wassermann reaction alone is a closer approximation to the facts than is obtained by the method used in Table III.

Table IV is compiled in accordance with the method used in the other surveys on enlisted men in the United States where the number of syphilitics actually under treatment was known. This table also shows the undoubted syphilitics a little lower than is shown by Table III, while the probable syphilitics are somewhat higher, and the same reasoning will explain the slight discrepancy.

TABLE IV.—*Calculation of number and per cent of syphilitics by same method used in other surveys on enlisted men.*

Number examined.	Known syphilitics.		++		Total undoubted syphilitics.		+		Total probably syphilitic.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
531	[1] 72	13.55	[2] 153	28.81	225	42.37	[3] 72	13.55	297	55.93

[1] 46++, 10+, 2+−, 14−. [2] 199++, −46 known syphilitics. [3] 82+, −10 known syphilitics.

The facts, as shown in this table, would seem to indicate that syphilis is extremely prevalent among the enlisted men of the Porto Rican Regiment as compared with white enlisted men in the United States, since the estimates in both cases are made according to the same method. If the facts presented and the deductions drawn from them are correct, they can only be explained on the supposition that syphilis is extremely common among the civil population of the island, since syphilis in soldiers can only be acquired from the civilian population, and that sexual morality is probably on a lower plane than obtains among the white enlisted men in the United States. The latter will appear quite probable to anyone who had had some experience in Latin-American countries in the Tropics. This would seem to indicate that possibly syphilis as well as hookworm infestation is important in the production of the anemias and debilitated conditions said to be so common among the poorer inhabitants of Porto Rico. Several of the double plus cases in this series were diagnosed as anemia without hookworms. The writer is inclined to believe that too much importance has been ascribed to the hookworm, particularly in our Southern States. Syphilis, tuberculosis, malaria, and malnutrition may not sound so romantic as hookworm disease, but no arguments are necessary to demonstrate their potency in undermining the health of a population.

While no attempt has been made in this bulletin to investigate the prevalence of chancroids and gonorrhea, the history of each man was given with regard to these diseases by Maj. Dutcher. The statistics of all venereal infections have therefore been compiled in Table V, showing also the number of cases having a history of having had two or all three of the venereal infections. No attempt, however, has been made to tabulate duplicate admissions for the same disease, of which there were many instances, some men having had gonorrhea or chancroids on three or four separate occasions.

TABLE V.—*Showing diagnoses for all three veneral diseases.*

Disease.	Number.	Per cent.
History of syphilis	72	13.55
History of chancroids	106	19.96
History of gonorrhea	123	23.16
Syphilis and chancroids	26	4.89
Syphilis and gonorrhea	27	5.08
Chancroids and gonorrhea	39	7.34
Syphilis, chancroids, and gonorrhea	12	2.26
No history of venereal infection	259	48.77

It will be seen from this table that there are less than 50 per cent of the entire command that have not been on sick report for venereal disease. Many men have been frequently on the sick report for one venereal condition after another. Such figures tend to show that the prevalence of syphilis has probably not been exaggerated among these men, since the opportunities to acquire it must have occurred pretty frequently. They also indicate that education can not be expected to be of great service as a preventive of sexual immorality and venereal infections. If men who have already experienced the effects of venereal disease are not thereby educated to abstain from vice, but persist, although infected again and again, how can it be expected that merely telling men what is likely to happen to them will produce the slightest effect. One might as well shoot peas at a battleship. So far as the Army is concerned, while instruction with regard to the effects of venereal disease should be given from moral considerations, little reliance should be placed on such instruction as a preventive of venereal diseases. An intelligent venereal prophylaxis, rigidly enforced, is the only measure that can effect much reduction in the prevalence of venereal diseases among troops.

PART III.

THE PREVALENCE OF SYPHILIS AMONG SOLDIERS THAT HAVE RECENTLY LEFT THE SERVICE.

THE PREVALENCE OF SYPHILIS AMONG MILITARY CONVICTS.

In studying the causes whereby syphilitics become separated from the military service, as indicated by the syphilitic registers of completed cases, the surprising fact was discovered that apparently desertion and convictions by general court-martial were considerably less frequent among these syphilitics than among enlisted men taken as a whole. This suggested the desirability of making a study of the prevalence of syphilis among military convicts. Steps were at once taken, therefore, to secure a Wassermann survey of the prisoners in the military prisons at Fort Jay and at Fort Leavenworth. At Fort Jay the blood specimens were collected and sent through the courtesy of Capt. George H. Scott, Medical Corps. At Fort Leavenworth it was found that a similar survey had already been commenced independently by Capt. Charles F. Craig, Medical Corps, and 290 men had already been examined. But after hearing that I desired to include the prisoners at Leavenworth in the general study of syphilis in the Army, Capt. Craig very generously withdrew from this work and sent me the records of the 290 men already examined by him. The blood from the remaining prisoners was collected and sent to the Army Medical School by Lieut. Edgar F. Haines, Medical Reserve Corps. I wish to acknowledge my indebtedness to all of these officers. In making this survey all men known to have syphilis and under treatment for that disease were excluded. The results obtained by the application of the Wassermann reaction to the remaining men may be seen in the following table:

TABLE I.

	Number examined.	++		+		±		−	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Fort Leavenworth (Craig).	290	31	10.19	18	6.20	6	2.06	235	81.03
Fort Leavenworth(Vedder)	610	57	9.34	38	6.23	48	7.87	467	76.55
Fort Jay (Vedder).........	163	13	7.97	9	5.52	6	3.62	135	82.82
Total................	1,063	101	9.50	65	6.11	60	5.64	837	78.72

Several points of interest are shown by a study of this table. In the first place, Capt. Craig and I were using the same Wassermann reaction. It might, therefore, be supposed that our results would be similar. Nevertheless it afforded some pleasure to see how very closely the two sets of figures corresponded, because this provides a satisfactory demonstration that the Wassermann reaction is adapted to the purpose for which it is used here, since two workers can obtain identical results with it, and also that the figures above must be an accurate index as to the amount of syphilis among military prisoners, so far, at least, as this may be ascertained by the use of the Wassermann reaction.

The next point is that the percentage of double plus and plus reactions obtained from the survey at Fort Jay was preceptibly lower than the percentage obtained at Fort Leavenworth. This may be purely a coincidence, and may be due to the fact that the number of men confined at Fort Jay constitutes too small a group upon which to base conclusions.

In estimating the amount of syphilis among the prisoners it is necessary to add the known syphilitics whose blood was not tested to the positive reactions obtained among the remainder of the prisoners. It is difficult to fix the exact number of known syphilitics, for the reason that these men are coming and going during the year, and the number therefore varies considerably at different times.

To avoid this difficulty it was determined to take the number of known syphilitics in the prison on a single day. Maj. Kent Nelson, Medical Corps, the prison surgeon, informed me that on August 28, 1914, at the time of beginning of the survey, there were in the prison 82 diagnosed cases of syphilis.

Capt. George H. Scott, Medical Corps, surgeon at Fort Jay, informed me that there were no known syphilitics among the prisoners at Fort Jay at the time the survey was made, although at other times there had been a number of such cases under treatment.

On the basis of these figures, the following table may be constructed to show the amount of syphilis among the prisoners:

TABLE II.

	Number examined.[1]	Known syphilitics.	++ Wassermann.	Total undoubted syphilitics.		Probably syphilitic + Wassermann.		Total estimated syphilitics.	
				Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
Fort Leavenworth	982	82	88	170	17.31	56	5.70	226	23.01
Fort Jay	163	0	13	13	7.97	9	5.52	22	13.49
Total	1,145	82	101	183	15.98	65	5.67	248	21.65

[1] 1,063 cases in which Wassermann reaction was performed plus known syphilis.

Adding together the 15.98 per cent of known syphilitics and the 5.67 per cent of probable syphilitics, we may estimate the amount of syphilis among prisoners at 21.65 per cent.

It will be seen that this is 5.57 per cent higher than the estimated amount of syphilis among the enlisted men of the Army (16.08).

It must be remembered, however, that this higher per cent of syphilis among military prisoners is partly due to the large percentage of known syphilitics furnished by Maj. Nelson. Thus the percentage of known syphilitics at Leavenworth was 8.35 per cent, as compared with 3.44 per cent of known syphilitics for the enlisted men of the Army. It may be possible that the supposed greater prevalence of syphilis among military prisoners is to be explained partly by the variations in the number of men who are diagnosed and treated for syphilis. This factor, of course, depends entirely upon the activity of particular surgeons in this direction, and it is important to note that Maj. Nelson has been unusually active in this direction at Fort Leavenworth. Thus, in his report for the year 1914, (see report of Judge Advocate General, 1914, p. 28) Maj. Nelson states:

> Venereal disease has received careful attention. Upon entry all men are carefully examined for disease. Some conceal the facts at first, but after a few days of hard labor are quite willing to use any means to escape work. This gives us complete control of the situation, and practically all cases are found, carefully treated, and recorded. For example, in the year ending June 30, 1912, before my service began at this station, there were treated during the entire year 57 cases of venereal disease. During the year ending June 30, 1914, there have been treated 338 cases.

Of these 338 cases 136 were syphilitic. However, this large number of known syphilitics in the military prison at Fort Leavenworth is not believed to be an adequate explanation for the high figures obtained among military prisoners in this survey. For if we compare the results of the Wassermann surveys alone, excluding known syphilitics, and counting both double plus and plus reactions, we find 16.77 per cent of positive reactions among accepted recruits, 12.64 per cent among the white enlisted men of the Army, and 15.61 per cent among the military prisoners. We must, therefore, believe that there is really more syphilis among military prisoners than among enlisted men of the Army, and there is a fairly obvious explanation for this difference. These figures certainly afford some ground for the supposition that many of the syphilitic recruits are undesirable characters in other respects as well, and that one reason why there are fewer syphilitics in the Army than among recruits is because a considerable percentage of these syphilitic recruits soon find their way into military prisons. This point will be discussed further later.

This study also throws considerable light on the general subject of the prevalence of syphilis. The control of these prisoners was doubtless very rigid, and every effort appears to have been taken to detect venereal disease. That this effort was conscienscious and as effective as any physical examination without a Wassermann is likely to be is shown by the very high percentage of cases of syphilis actually detected. Under these circumstances it was most natural that Maj. Nelson should suppose that "practically all cases are found, carefully treated, and recorded." Yet a Wassermann survey of the remaining prisoners show approximately 10 per cent of double plus and 6 per cent of plus reactions. This indicates that under ordinary circumstances by far the greater amount of syphilis in any group is never discovered. The individual examined may either be ignorant of the infection or he may conceal it. In either case the majority of the cases are not detected by the usual physical examination. The addition of the Wassermann reaction detects the majority but not all of these cases. A considerable percentage of the total syphilitics escape even this test. If all prisoners having a plus-minus reaction were tested by the provocative reaction, or if all the prisoners having a plus-minus or negative Wassermann were tested by luetin, a much higher percentage would be detected. It is evident that the more careful and intensive the study of any given group of men the higher becomes the percentage of syphilis detected. From this it may be deduced that the majority of estimates as to the prevalence of syphilis in the community are far too low, since in no case are they based on such a thoroughgoing examination as is here described.

THE PREVALENCE OF SYPHILIS AMONG INSANE SOLDIERS AT THE GOVERNMENT HOSPITAL FOR THE INSANE.

A number of soldiers become insane while in the service and are sent to the Government Hospital for the Insane. Thus Capt. King's report on Mental Disease and Defect in the United States Troops, Bulletin No. 5, Office of the Surgeon General, states that during one year 77 enlisted men, 4 officers, and 7 general prisoners, or a total of 89, were admitted to the Government Hospital for the Insane during one year. A study of syphilis in the Army, therefore, necessitates an attempt to investigate the prevalence of syphilis among the insane soldiers at this institution and to determine the importance of syphilis as a cause of this insanity.

When this subject was first broached it was found that Dr. William H. Hough, in the course of his duties as clinical pathologist at the hospital, had already made a careful study of a number of these soldiers, including a Wasserman reaction of the serum of all cases, and a study of the spinal fluid in all cases suspected of paresis or cerebral syphilis. In view of the careful work that had been performed by Dr. Hough, it would have been a waste of time to repeat this examination in the cases already studied by him. I therefore agreed with Dr. Hough to make a Wassermann survey on as many cases as possible in which the Wassermann reaction had not already been performed by him. The results of this combined work, including a study of 1,283 cases, were published (The Prevalence of Syphilis Among the Inmates of the Government Hospital for the Insane, Journal A. M. A., 1915, LXIV, 972), with the following conclusions:

1. That among white men the presence of syphilis has been demonstrated in 20 per cent of the cases.
2. We estimate that at least 30 per cent of the white males in this institution are syphilitic.
3. That at least 10 per cent of the insanity in this institution is directly attributable to syphilis.

In the above study, many negroes and females of both races were included. All white males were classed together, and no attempt was made to study the prevalence of syphilis among soldiers, as a relatively small number of soldiers had been studied at the time this paper was published. I therefore continued this survey work, with the result that, including Dr. Hough's cases and my own, a study of

1,129 insane white males, of whom 567 were insane soldiers, is here presented. The results of this investigation are indicated in the following tables:

TABLE I.

	Number examined.	Known syphilitics.		++ Wassermann.		+ Wassermann.		+− Wassermann.		− Wassermann.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Army	567	20	3.51	47	8.29	42	7.41	56	9.87	402	70.90
Navy	182	14	7.69	11	6.04	8	4.40	18	9.89	131	71.97
Civilians	380	38	10.00	15	3.94	19	5.00	24	6.31	284	74.73
Total insane	1,129	72	6.36	73	6.45	69	6.09	98	8.67	817	72.36

TABLE II.

	Undoubted syphilitics.		Total.		Probable syphilitics.	Total estimated syphilitics.	
	Syphilitics	++Wassermann.	Number.	Per cent.	+Wassermann.	Number.	Per cent.
Army	20	47	67	11.80	42	109	19.21
Navy	14	11	25	13.73	8	33	18.13
Civilians	38	15	53	13.94	19	72	18.94
Average per cent				13.15			18.76

The cases called known syphilitics were usually cases of paresis or cerebral syphilis and were not included in the Wassermann survey. The cases in which the Wassermann reaction was performed were taken at random by simply taking all the men in certain buildings.

Several interesting points are brought out by a study of these tables. In the first place, the percentage of known syphilitics is very small for the Army (3.51) as compared with the Navy (7.69) or with civilians (10). Some of this discrepancy may be due to the error inherent in the comparison of small groups, but more is due to the fact that many Army cases were studied soon after admission to the hospital and before the diagnosis was made. Where there were few known syphilitics the percentage of double plus Wassermann reactions was high and vice versa.

There is apparently no great variation in the amount of syphilis among the inmates from these three different sources. While undoubted cases of syphilis are apparently lower for the Army (11.8) than for the Navy (12.73) or for civilians (13.94), this relationship is almost reversed when undoubted cases and probable cases are classed together, and the Army is apparently a little higher (19.21) than the Navy (18.13) or than civilians (18.94).

Nothing can be more certain than the fact that all syphilitic cases have not been detected by this examination, based in most instances on a single Wassermann reaction. We may, therefore, estimate that syphilis is prevalent among insane soldiers to the extent of at least 20 per cent.

While in many of these cases syphilis is merely an incident and does not stand in any direct causal relationship to the insanity, yet in all cases of paresis and cerebral syphilis the insanity is to be directly attributed to syphilis.

Vedder and Hough (loc. cit.) found in 616 cases 62, or 10.06 per cent, cases of paresis or cerebral syphilis, and concluded that at least 10 per cent of the inmates in the Government Hospital for the Insane owed their insanity directly to syphilis. The percentage would have been higher had only white males been considered, for of 473 white insane males, of whom a reasonably complete study has been made, those suffering from paresis and cerebral syphilis constituted 13.07 per cent. The percentage for the Army was 12.90, for the Navy 13.63, and for civilians 12.70. It is therefore clear that, so far as the Army is concerned, about 13 per cent of the soldiers sent to the Government Hospital for the Insane are insane as a direct result of a syphilitic infection; or if syphilis were eliminated from the service there would be 13 per cent less insanity developing in the service than is the case at present.

The figures obtained in this survey are compared in Table III, with the figures for recruits and for white enlisted men.

TABLE III.

	Known syphilitics.	Wassermann + +	Wassermann +	Total estimated syphilitics.
Recruits	0	7.75	9.02	16.77
Enlisted men	3.44	4.77	7.87	16.08
Insane soldiers	3.51	8.29	7.41	19.21

From this table it may be seen that syphilis is certainly more prevalent among insane white soldiers than among white enlisted men in the service. It is therefore a fair deduction that syphilitics tend to become eliminated from the service in this way and that we have here another reason why there is less syphilis among enlisted men than among recruits.

THE PREVALENCE OF SYPHILIS AMONG THE PATIENTS AT THE ARMY HOSPITAL FOR TUBERCULOSIS AT FORT BAYARD, N. MEX.

It has long been known that an infection with syphilis predisposes to a tuberculous infection, and a famous clinician expressed this by the statement "Syphilis makes the bed for tuberculosis." Recently there have been several investigations confirming this opinion. Thus Letulle, Bergeron, and Lepine,[1] say:

> The clinical and pathological investigations which we have pursued for several years confirm us in the conviction that the hidden or latent manifestations of syphilis greatly surpass in importance the manifest lesions of the disease, because of the multitude of chronic visceral affections so produced. The great frequency of positive Wassermann reactions among hospital patients suffering from diseases of liver, kidneys, of the cardio-vascular apparatus or of the nervous system suppports this belief.
>
> For a long time the clinician has accused syphilis of preparing the ground for the tubercle bacillus. For more than a year we have performed the Wassermann on all tubercular patients, male or female, without any selection on their entry to the hospital Boucicaut. Thus of 346 known tuberculous patients, 64 gave positive reactions and 8 doubtful, so that of 100 taken at random 19 are positive. This is conservative, because the Wassermann, as is well known, does not detect all cases of latent syphilis, and moreover does not count the doubtful reactions, which according to our experience should really be called feebly positive. It is safe to state that 1 out of every 5 tuberculous is at some time in an active state of syphilitic infection.
>
> Out of these 64 patients 10 knew that they were infected with syphilis and admitted it; 19 patients with a positive Wassermann came to autopsy and 14 presented an aorta more or less profoundly altered.
>
> In Paris among the patients in hospital for pulmonary tuberculosis one-fifth, at least, suffer from syphilis more or less latent but which is still in full activity. This is shown by the Wassermann and confirmed at all points by our anatomo-pathologic investigations.

The investigations of Bronfenbrenner[2] indicate that the converse of this proposition is also true; i. e., that many syphilitics suffer at the same time with tuberculosis.

Bronfenbrenner found that a very high percentage of those infected by syphilis gave a complement fixation for tuberculosis, as compared with individuals that did not suffer from syphilis. Thus he studied 625 cases, of which 108 were diagnosed as syphilis, and 85 gave a positive Wassermann reaction, though admitted to hospital for other causes. This makes a total of 193 syphilitics studied. Of these, 83 gave a positive tuberculin complement fixation reaction, being about 43 per cent. Of these cases, tuberculosis was clinically diagnosed or strongly suspected in 55 cases, leaving 28 cases of syphilis giving a positive reaction (tuberculin) but in whom the presence of tuberculosis had not been suspected. The rate of positive tuberculous reaction in syphilitics in whom tuberculosis was not previously suspected is about 20.3 per cent.

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[1] The Wassermann Reaction in Pulmonary Tuberculosis. Bull. de l'Acad. de Med. Paris, 1914, LXXI, 596.

[2] The Complement Deviation Test with Besredka's Tuberculin and the Occurrence of Tuberculosis among Syphilitics as Diagnosed by the Test. Archives of Internal Medicine, Dec. 15, 1914, Vol. XIV, p. 786.

Nonsyphilitics examined were 432 (625–193). Out of this number only 100 gave a positive tuberculin fixation reaction, or about 23.15 per cent, as compared with 43 per cent in syphilitics. Among these cases tuberculosis was diagnosed or strongly suspected in 80 cases. Bronfenbrenner concludes that "the frequent simultaneous occurrence of the complement deviation test with Besredka's antigen and the Wassermann reaction in syphilitics is due to the fact that either syphilis as such or the antisyphilitic treatment markedly lower the resistance of the patients so as to make them either more susceptible to new infection to tuberculosis or to render them less resistant against the progress of this disease previously contracted."

Such findings indicated the desirability of investigating the prevalence of syphilis among soldiers discharged from the Army for tuberculosis. Such patients are sent to the Army General Hospital at Fort Bayard, N. Mex., and permission was secured from the Surgeon General to obtain a Wassermann survey on these patients. The blood specimens for this purpose were collected from all tuberculous patients at the hospital at the time the survey was made, with the exception of 9 cases, who were too ill, and 18 cases having a history of a syphilitic infection. The blood specimens were collected by Lieut. George R. Callender, Medical Corps, to whom I desire to express my obligation for this service. The Wassermann reactions were performed at the laboratory of the Army Medical School as promptly as possible after the specimens were received, and the results of this survey are shown in Table I.

TABLE I.—*Wassermann survey of patients at Fort Bayard.*

Number examined.	+ +		+		+ –		–	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
211	36	17.06	36	17.06	49	23.22	90	42.65

I was informed by Col. George E. Bushnell, Medical Corps, in command of this hospital, that at the time this survey was taken there were 238 patients in the hospital, among whom 18, or 7.56 per cent, had a history of having had syphilis, but whose blood was not included in the above Wassermann survey. In 9 cases the blood was not sent, because the patients were too ill, so that actually 229 cases were included in this survey. Seven and fifty-six one-hundredths per cent of 229 men actually examined is 17.31, which number is, therefore, used for known syphilitics instead of 18. The amount of undoubted and probable syphilis at Fort Bayard, estimated in accordance with the method used in other surveys in this series, is shown in Table II.

TABLE II.

Number examined.	Known syphilitics.		+ + Wassermann.		Total undoubted syphilitics.		+ Wassermann.		Total probable syphilitics.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
229	17.31	7.56	36	15.72	53.31	23.28	36	15.72	89.31	39.00

In the interpretation of these results several facts must be considered. A comparatively small number of cases were examined, and these figures are therefore open to this criticism.

Again the possibility may be suggested that tuberculosis alone may give a certain percentage of positive Wassermann reactions. This can hardly be denied categorically. No claim can be made for the specificity of the Wassermann, and it is known that in certain conditions, such as diabetes, an acidosis will result in a false positive Wassermann reaction. Under these circumstances there is a possibility that some of these reactions may be false positives. But this is not believed to be the case. Investigations that have been made have failed to show that tuberculosis per se gives a Wassermann reaction. Such false positives therefore, if they occur at all, must be quite rare.

Still further, the percentage of known syphilitics is a good indication that the Wassermann reaction has not run unduly high in this survey. Eighteen patients out of 238, or 7.56 per cent, are admitted to have had syphilis. The percentage of known syphilis among enlisted men of the Army is only 3.44, so that it is clear from the sick report alone that the prevalence of syphilis among the tuberculous is more than twice as great as among the enlisted men on duty in the service.

The total number of undoubted syphilitics according to this estimate (23.28 per cent) is almost identical with the results obtained by Letulle, Bergeron, and Lepine in Paris, i. e., 1 out of 5 tuberculous patients are also syphilitic. Like the figures from Paris, this estimate does not include partial reactions or doubtful cases. The amount of syphilis among the tuberculous patients, if estimated in accordance with the usual method used in these surveys, is considerably higher, i. e., 39 per cent.

If this is true, it may possibly explain the alleged efficacy of succinimide of mercury as a cure for pulmonary tuberculosis. It may be remembered that several years ago Dr. Barton Lisle Wright, of the Navy, advocated this treatment and reported great improvement in tuberculous cases following its use. The writer is inclined to believe that the actual results obtained by Dr. Wright following this treatment were not in the least exaggerated, but that the conclusion that tuberculosis is thereby cured is an error. If this large percentage of the tuberculous suffer from syphilis, it is more probable that when mercurial injections were used on a number of tuberculous patients in many cases their syphilitic infection was controlled, thus giving them sufficient strength and physical resistance to overcome their tuberculous infection.

If there is the slightest truth in this supposition, it follows that energetic antisyphilitic treatment should form an indispensable part of the treatment of tuberculosis in all cases in which there is a coexistent syphilitic infection. How can we expect fresh air and good food alone to cure a patient who is being slowly dragged down by an untreated syphilitic infection? It would seem clear that a Wassermann reaction should be made in all cases admitted to the general hospital for tuberculosis and that all cases in which a syphilitic infection is detected be given active antisyphilitic treatment in order that they may thereby be assisted to overcome their tuberculous infection.

The comparative prevalence of syphilis among recruits, enlisted men, and the tuberculous is shown in Table III.

TABLE III.

	Known syphilitics.	Wassermann. + +	Wassermann. +	Total estimated syphilitics.
Recruits	0	7.75	9.02	16.77
Enlisted men	3.44	4.77	7.87	16.08
Tuberculous	7.56	15.72	15.72	39.00

In view of these figures and the view already expressed with regard to the liability of syphilitics to contract tuberculosis, it must seem certain that there is a tendency for syphilitics to leave the service by this route. But it is probable that this tendency is of no great importance in reducing the percentage of syphilitics actually in the service, because there are relatively so few tuberculous.

Since by all means we desire to reduce the prevalence of tuberculosis in the service, this affords another argument for the elimination of the syphilitic recruit. If this were to be accomplished it might be confidently expected that there would be a notable decrease in the rate for tuberculosis in the service.

THE PREVALENCE OF SYPHILIS AMONG THE INMATES OF THE UNITED STATES SOLDIERS' HOME, WASHINGTON, D. C.

The medical officers who have served at the Soldiers' Home have been convinced that a considerable proportion of the inmates were infected with syphilis. It was highly desirable to obtain a survey of the inmates of the home, because they consist of a large number of old men who have served a number of years in the Army or who have become disabled in the military service. The Army Regulations state that an honest and faithful service of 20 years in the Army or a disability contracted in the line of duty entitle a soldier to admission to the Soldiers' Home. All of these men have, therefore, been in the Army for various periods, and many of them for a considerable length of time. Since we have investigated the amount of syphilis in recruits entering the Army and in the soldiers actually in the Army, it follows that a survey of the old and disabled soldiers will be of value for purposes of comparison.

Moreover, while many of these men have served a considerable period in the Army, many of them have also lived a long time at the home or at various other places since their discharge from the Army. Such old and decrepit individuals form a certain percentage of the community at large. Since we have every reason to believe that, notwithstanding public opinion, there is no more syphilis acquired in the Army than among similar individuals in civil life, it follows that the amount of syphilis existing among these inmates may be taken as a tolerably fair index of the amount of syphilis to be found among the old and decrepit portion of the general male population.

In pursuing this investigation I have had the active assistance and cooperation of the authorities of the Soldiers' Home, and more particularly of Lieut. Col. James D. Glennan, Medical Corps, the surgeon at the home, to whom I desire to express my thanks for the interest that he has taken in this work.

The inmates of the home.—The inmates are all men, with a very few exceptions, belonging to the white race. A considerable proportion are of German or Irish descent. The physical condition of these men varies considerably. A number are in the home because they are too aged to care for themselves, but aside from the debilities inseparable from age are otherwise in good condition. Another considerable number have suffered from disability, such as the loss of an arm or leg, but are otherwise well. A few are blind, some have been disabled by chronic dysentery and other diseases contracted in the military service. There is a large hospital connected with the home where many of these chronic cases spend most or all of their time. Thus it will be seen that while any inmate of the home may be admitted to the hospital for some temporary disability, yet there are a considerable number of the inmates who reside there permanently, and some of these suffer from conditions that are manifestly of syphilitic origin, such as locomotor ataxia, aneurism, etc. It has, therefore, been thought advisable to consider the inmates in the hospital and those in the home proper in separate classes, although it must be borne in mind that at the time the survey was made a considerable number of the patients in the hospital were there temporarily. There are no insane patients at the home, since all insane soldiers or inmates of the home who become insane are sent to the Government Hospital for the Insane.

The residents of the home form a floating population, since new men are entering continuously, and some are discharged or leave voluntarily when the life no longer suits them, and, of course, owing to the high percentage of old and infirm there is a high percentage of deaths. This investigation has occupied several months, during which time every inmate of the home and all new admissions were examined, so that there has been no selection of cases. However, owing to the fact that these men can leave whenever the fancy takes them, there are a considerable number of the cases reported in this series in which a complete examination was not made. Thus the Wassermann may have been taken and the man left before the luetin reaction could be performed. But, while our information with regard to this series of cases is not as complete as might be desired, it may be fairly claimed that it is as complete as it was possible to make it under the limitations necessarily imposed.

The age of the inmates is a matter of importance in an investigation of this character, and may be shown by the following table, in which the age is tabulated by decades:

Table I.—*Distribution of 1,171 inmates according to decades of age.*

Age	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100
Per cent	0.8	4.0	7.2	18.0	35.8	29.6	4.6	0

From this table it may be seen that 83.4 per cent of the inmates of the home are between 50 and 80 years of age, and that practically none of them are under 30 or over 90 years of age.

The first part of the examination of these inmates consisted in taking a Wassermann reaction in every case. The blood was collected at the home and sent by messenger to the Army Medical School, where all the reactions were performed.

The following table shows the results obtained by this Wassermann survey:

TABLE II.—*Wassermann survey of 1,171 inmates of the soldiers' home.*

	Total number examined.	+ +		+		+ −		−	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
In home proper............	550	59	10.7	29	5.2	83	15.08	379	68.08
In hospital of home........	621	97	15.6	85	13.6	93	14.9	346	55.7
Total	1,171	156	13.4	114	9.7	176	15.0	725	61.9

At the time the specimens of blood were taken a brief history with regard to venereal disease was taken from each man. He was asked if he had ever had a sore; and if so, on what date. Questions were also asked to determine the possible occurrence of secondaries or other symptoms of syphilis, and to determine whether treatment for syphilis had ever been received. In addition to this information obtained from all cases, a more or less complete clinical examination was available in the case of all those men who had been in the hospital. The results obtained from the Wassermann survey were then combined with the information obtained from this clinical examination. In this connection it is clear that while the admission of syphilis or of possible history of the disease is of positive value, the denial of all venereal history, which was the case in a very large number of cases, is of even less value than is generally the case. The men at the home are in many cases receiving pensions from the Government, or hope to receive them, and venereal diseases being not in line of duty are naturally disclaimed in order not to adversely affect an otherwise pensionable status. At the same time a very considerable amount of positive evidence was obtained as a result of this examination.

In case the result of the Wassermann was double plus or a clear negative, no further attempt to study these cases was made, but in the case of partial reactions, and particularly in the case of plus reactions, the majority of which we feel sure are due to syphilis, a further and more careful history was taken.

Combining the results of the clinical survey with the Wassermann survey, and considering all double plus cases, all plus cases having a corroborative history of syphilis or actual symptoms of syphilis, and all plus-minus and negative reactions that have received or were receiving treatment for syphilis as undoubted syphilitics, the following results were obtained:

Undoubted syphilis—In the home proper.

Double-plus reactions	59
Plus reactions having corroborative syphilitic history or physical signs	17
Plus-minus reactions that had received treatment for syphilis	3
Minus reactions that had received treatment for syphilis	10
Total undoubtedly syphilitic	89

The remaining plus cases, in whom no corroborative history or physical signs could be obtained, the remaining plus-minus cases, and also the cases having a negative Wasserman but having a history that was suspicious, but not sufficient to warrant a positive diagnosis, were then grouped as doubtful cases, as follows:

Doubtful cases—In the home proper.

Remaining plus reactions	12
Remaining plus-minus cases	80
Negative reactions that gave a history of a sore or of other symptoms that might have been syphilis	21
Total doubtful cases	113

Subtracting the positive and doubtful cases from the total number of cases examined, we, therefore, found 348 negative cases out of the 550 examined.

With regard to the cases studied in the hospital of the home, the results were combined in precisely the same way, except that it must be remembered that here we had a much more complete history and physical examination at our disposal. The results obtained were as follows:

Undoubted syphilis—In the hospital of the home.

Cases having a double-plus reaction	97
Plus cases with confirmatory findings	50
Plus cases that have received treatment for syphilis	15
Plus-minus cases that have received treatment for syphilis	18
Negative cases that have received treatment for syphilis	24
Total cases undoubtedly syphilitic	204

Doubtful cases—In the hospital of the home.

Cases having a plus reaction but no confirmatory findings	20
Cases having a plus-minus reaction. Many of these cases had some history or physical signs, but insufficient to make a positive diagnosis	75
Cases having a negative reaction but a suspicious history or physical signs	29
Total doubtful cases	124

Substracting the positive and doubtful cases from the total 621 cases examined, there remain 293 negative cases.

These results are shown more clearly in the following table:

TABLE II.—*Combined Wassermann and clinical survey of 1,171 inmates.*

	Total examined.	Undoubted syphilis.		Doubtful.		Negative.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
In home proper	550	89	16. 1	113	20. 5	348	63. 2
In hospital of home	621	204	32. 8	124	19. 9	293	47. 1
Total	1, 171	293	25. 0	237	20. 2	641	54. 7

In order to obtain further information with regard to these cases it was intended to perform a luetin reaction on all of these 1,171 men, with the cooperation of Lieut. William B. Borden, Medical Corps. However, we found that during the several months occupied with the previous examination many of our cases had died, had left the home, or were temporarily absent, so that we were only able to perform the luetin reaction on 744 of the 1,171 cases.

The luetin used was very kindly furnished by Dr. Hideyo Noguchi, of the Rockefeller Institute for Medical Research, to whom we are very much indebted for this favor. The luetin as received was diluted with an equal part of 0.8 per cent salt solution, and 0.08 c.c. was injected into the skin of the upper arm, great pains being taken to insure the production of an intradermic injection. Three readings were made on all of these cases 7, 14, and 21 days later, or as near those dates as practicable, and the results were recorded as double plus, plus, plus minus, and minus.

These readings and their interpretation and the comparison of the results obtained in the same individual from the application of the Wassermann reaction and the luetin test have all been discussed elsewhere.[1] It is therefore only necessary to show here how the results of this luetin test affected the syphilitic survey made on these men. For this purpose we may ignore all luetin results in those cases already known to be syphilitic, simply adding to the known syphilitics all of those doubtful or negative cases that gave a plus or double plus luetin reaction. In accordance with this procedure the following results were obtained:

In the home proper.—Among the 113 doubtful cases, 2 cases having a plus Wassermann gave a double-plus luetin, 6 cases having a plus Wassermann gave a plus luetin, 1 case having a plus-minus Wassermann gave a double-plus luetin, 12 cases having a plus-minus Wassermann gave a plus luetin. This makes a total of 21 cases that can be removed from the doubtful column and added to the positive column.

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[1] Vedder and Borden. A Comparison of the Wassermann and Luetin Reactions in 744 Individuals. J. A. M. A., 1914, LXIII, 1750.

Among those cases giving a negative reaction 13 cases gave a double-plus luetin and 66 gave a plus luetin, making a total of 79 cases to be removed from the negative column and added to the positive column, as follows:

Positive cases from Table II	89
Cases that were doubtful in Table II and added to the positives as a result of the luetin test	21
Cases that were negative in Table II and added to the positives as a result of the luetin test	79
Total positively syphilitic	189

Subtracting these 21 cases from the 113 doubtful in Table II leaves a total of 92 doubtful cases.

Subtracting the above 79 cases from the 348 negative cases in Table II leaves a total of 269 negative cases.

In the hospital of the home.—Among the 124 doubtful cases, 2 of the cases having a plus Wassermann gave a double plus luetin, 3 of the cases have a plus Wassermann gave a plus luetin, 3 of the cases having a plus minus Wassermann gave a plus luetin, 5 of the cases having a negative Wassermann reaction gave a plus luetin, making a total of 18 cases removed from the doubtful to the positive column.

One of the cases having a negative Wassermann gave a double plus luetin and 27 of the cases giving a negative Wassermann gave a plus luetin. This may be summarized as follows:

Positive cases from Table II	204
Cases that were doubtful in Table II and now added to the positives as the result of the luetin test	18
Cases that were negative in Table II and added to the positives as the result of the luetin test	28
Total positively syphilitic	250

Subtracting the 18 cases from the 124 doubtful cases in Table II leaves a total of 106 doubtful cases.

Subtracting the above 28 cases from the 293 negative cases in Table II leaves a total of 265 negative cases.

These results may be tabulated as follows:

TABLE III.—*Combined Wassermann. clinical and luetin survey.*

	Total examined.	Undoubted syphilis.		Doubtful.		Negative.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
In home proper	550	189	34.36	92	16.72	269	48.90
In hospital of home	621	250	40.25	106	17.07	265	42.67
Total	1,171	439	37.49	198	16.90	534	45.60

From this table it will be seen that using the Wassermann reaction, the clinical history, and the luetin reaction 37.49 per cent of the inmates of the Soldiers' Home may be regarded as undoubtedly syphilitic, while 16.9 per cent are doubtful and 45.6 per cent are negative. In considering these results it must be understood that no claim is made that the positive findings by the luetin reaction can be accepted with the same confidence that is placed in the Wassermann reaction, since there is no such general consensus of opinion with regard to the interpretation of the luetin reaction as exists in the case of the Wassermann reaction. However, the writer is inclined to believe that as used in these cases, the double plus and plus reactions are indicative of a syphilitic infection. For the rest it may be stated that in interpreting the histories and physical signs in these cases, and particularly in the case of patients with negative or plus-minus Wassermann or luetin reactions such cases have not been called syphilitic unless the clinical evidence was clear and convincing. It is believed, therefore, that the conclusion that 37.49 per cent of these inmates are syphilitic is well within the limits of caution.

Indeed, a higher estimate might well be made, for only a single Wassermann reaction was performed in these cases. The histories and examinations were necessarily brief in the case of inmates not in the hospital, and, finally, the luetin reaction was only performed in 744 of the 1,171 cases. It is interesting to note that in these 744 cases the combined Wassermann and luetin examinations resulted in 338 positives, counting both double plus and plus reactions, or a percentage of 45.4 positive reactions.

It may be accepted, therefore, without further argument that a more intensive study of these 1,171 cases would have reduced the number of doubtful and negative cases and swelled the number known to be syphilitic. For present purposes, however, it is sufficient to be certain that the percentage of 37.49 is conservative rather than an exaggeration.

Bearing this in mind, and the fact that has been emphasized sufficiently that there is less syphilis in the Army than among the same class of men in civil life, we may conclude that approximately 40 per cent of syphilis might be confidently expected in civil institutions devoted largely to the treatment of old men suffering from chronic diseases.

As in this study it has been possible to obtain the clinical histories, it is thought that a comparison of the estimate based on the Wassermann survey alone with the estimate based on the Wassermann reaction as interperted by the clinical history will be of interest. By the Wassermann survey alone there were 12.4 per cent of double plus reactions and 9.7 per cent of plus reactions. In accordance with the method used in other parts of this bulletin when no data but the Wassermann reaction was available, we would estimate that 12.4 per cent of the inmates were undoubtedly syphilitic, that 9.7 per cent more were probably syphilitic, and would place the total estimated syphilitics at 22.1 per cent. But when the Wassermann reactions were interpreted in the light of the clinical history 25 per cent of all the inmates were classed as undoubted syphilitics, with 20.2 per cent more doubtful. To be sure, in dealing with these old men there are a considerable number of very old infections, so that such a group would be expected to include a larger number of cases with a negative Wasserman but a positive history of syphilis than would be the case when younger men and more recent infections are studied. But allowing for this difference it appears that an estimate of syphilis based on the double plus and plus Wassermann reactions obtained in a survey is conservative and that therefore such estimates in this bulletin should not be criticized hastily.

It is obvious that no accurate comparison can be made between the prevalence of syphilis among the white enlisted men of the Army and the inmates of the Soldiers' Home owing to the fact that different methods were used in making the investigations. However, if it be assumed that all known syphilitics, double plus and plus Wassermann reactions, in the case of the white enlisted men, i. e., the total estimated syphilitics (16.08 per cent) may be compared with the result of the Wassermann as interpreted by the clinical history in the case of the inmates of the Soldiers' Home (25 per cent), it will be seen that by approximately the same method the percentage of syphilitics is much higher for the Soldiers' Home.

This certainly confirms the observation previously made that the percentage of syphilis in any given group increases steadily as the men grow older. It also clearly indicates that syphilis plays an important rôle in the production of those infirmities for which certificates of disability are granted to these old soldiers, and that there is a decided tendency for syphilitics to become eliminated from the service in this manner.

THE RELATIVE PREVALENCE OF SYPHILIS AMONG SOLDIERS THAT HAVE LEFT THE SERVICE, AS INDICATED BY A STUDY OF THE SYPHILITIC REGISTERS OF COMPLETED CASES.

The Syphilitic Register is a form authorized in March, 1911. When the diagnosis of syphilis is made in the case of an enlisted man one of these forms is filled out and thereafter accompanies the man as long as he remains in the service. When, for any reason, he leaves the service, this form is mailed to the Surgeon General, and all forms so received have been kept on file at the Army Medical School.

These forms, therefore, are supposed to contain a complete record of every known case of syphilis in the service since the adoption of this system. The actual results fall far short of this theory, since many records are very incomplete and many more have been lost. But an effort is here made to utilize the data that has accumulated in this way in order to determine in what way these known syphilitics leave the service and to compare the losses of known syphilitics with the losses for all enlisted men. Such a comparison should show whether syphilitics leave the service faster than nonsyphilitics and the reasons for this discrepancy. The records were investigated in 1914, and exactly three years, from 1911–1913, are included in this study.

From figures in the office of the Surgeon General, Maj. William J. L. Lyster, Medical Corps, furnished me with the actual number of cases of syphilis contracted by enlisted men during these years, as shown in Table I:

TABLE I.—*Actual cases of syphilis after deducting recurrent admissions.*

All American enlisted men.	Total.	Primary.	Secondary.	Tertiary.	Hereditary.	Period undetermined.	Acquired nonvenereally.
1911	2,919	312	2,288	301	18		
1912	2,224	374	1,601	201	11	30	7
1913	1,875	286	1,312	216	1	57	3
Total	7,018	972	5,201	718	30	87	10

From The Adjutant General's reports it is found that the actual number of American enlisted men was 73,454 in 1911, 81,331 in 1912, and 81,787 in 1913. That is, during these three years a total of

236,572 men acquired 7,018 cases of syphilis. During the same three years 95,302 men, or approximately 40 per cent of the total 236,572 enlisted men, left the service.

If there were no difference between syphilitics and nonsyphilitics with regard to their manner of leaving the service, we might assume that 40 per cent of the total infections (7,018), or 2,807 syphilitic men, would have left the service during these three years.

It is a fact, however, demonstrable by the syphilitic registers, that more than this number of syphilitics have actually left the service, for covering this period there are 3,300 syphilitic registers actually on file. This is 493 over and above the 2,807 that might be expected to leave the service if syphilitics leave no faster than other enlisted men. In other words, cases of syphilis are leaving the service faster than new cases are being contracted. This point is made much stronger if it be remembered that it is quite certain that more syphilitics have left the service than is shown by these registers. For while these registers are supposed to be mailed to Washington as soon as the men have left the service, some have certainly been lost. To assume that all have been sent in would be to assume an infallibility for this particular piece of paper work that all officers who have had experience in administrative positions will admit is improbable to say the least. It is only necessary to point out that during a large part of this time our troops have been scattered along the border on field service, which has rendered it very difficult to keep track of these registers, and several medical officers have informed me that numbers of registers have been lost in this way.

It is also of considerable interest to note that the figures for total syphilitic infections (7,018) include all the tertiary and hereditary cases. The latter were certainly not acquired in the service, and many of the tertiary and some of the secondary cases were probably acquired prior to enlistment.

We may therefore accept as the result of this study of the syphilitic registers that there is a decided tendency for these known syphilitics to leave the service faster than other enlisted men, and this conclusion is in harmony with the surveys on recruits and enlisted men, from which it appeared that there was rather less syphilis among enlisted men than among the recruits in spite of the infections acquired during the period of service.

It becomes a matter of some interest to know in what way these syphilitics have left the service. The exact losses of all enlisted men with the causes may be found in the annual reports of The Adjutant General, Table A. When a syphilitic leaves the service a notation is made on the register as to the manner in which the man has left the service. It is, therefore, easy to make a comparison between the percentage of losses of the entire enlisted personnel for any cause and the percentage of losses of syphilitics for the same cause, as shown by the registers.

As already stated, there were 3,300 registers covering the period investigated on file. Of this number there were 235 registers in which the desired information had not been furnished and it was impossible to learn in what way the man had left the service; 308 registers were sent in because the men were considered cured before they had left the service. In the majority of these cases the evidence on which this opinion was based did not conform to the standard of cure outlined in the instructions printed on the register. However, these cases were necessarily excluded, and there then remained 2,757 registers of men who had left the service to be analyzed. Table II shows the number and percentage of syphilitics who have left the service in the various possible ways, as compared with similar losses for all enlisted men as shown by the reports of The Adjutant General.

TABLE II.

Losses, all enlisted men.

Year.	Total number discharged.	Discharged, expiration term of service.	Discharged on surgeon's certificat of disability.	Discharged by general court-martial.	Discharged by order.	Deaths, all causes.	Deserted.
1913	37,514	25,027	1,006	2.855	3,935	414	3,882
1912	25,349	12,094	1,056	2,729	4,278	398	4,451
1911	32,439	21,187	1,046	2,290	3,795	361	3,411
Total	95,302	58,309	3,108	7,874	12,008	1,173	11,744
Per cent	100	63.28	3.26	8.26	12.62	1.23	12.32
Losses, syphilitics for the same years.							
Total	2.757	2,058	181	126	196	45	151
Per cent	100	74.64	6.56	4.57	7.11	1.63	5.44

From this it will be seen that deaths are higher among syphilitics than among all enlisted men. Discharges for disability are twice as high for syphilitics as for all enlisted men. This is only what might be expected. It is, however, somewhat surprising to find that 11 per cent more syphilitics remain to be discharged by expiration of term of service than is the case with all enlisted men, and that fewer syphilitics desert or are discharged by sentence of a court.

These facts may possibly be interpreted to mean that the soldier who suffers from syphilis realizes the fact that he is receiving excellent treatment free of charge, and consequently makes more of an endeavor to remain in the service than is the case with enlisted men as a whole. In this connection it is interesting to note that over 31,000 doses of salvarsan and neosalvarsan have been purchased and expended by the medical department of the Army up to the present date (October, 1914). When it is realized that if these men were in civil life they would have to pay $3.50 for every dose of this remedy, in addition to paying the physician for administering it, so that every dose would cost the patient from $10 to $25, and that if they were in civil life they would have to pay between $5 and $10 for every Wassermann test which they now have performed free of charge as often as the surgeon desires them, it is easy to understand the inducement for men under treatment for syphilis to remain in the service.

But whatever truth there may be in this argument, it can only apply to known syphilitics who are under treatment and not to those undiagnosed cases that are more numerous than the known syphilitics. The survey on military prisoners indicated a higher percentage of syphilis among these men than among white enlisted men of the Army. It may well be that while those men who are receiving treatment do not often desert or commit serious offenses, that many of the recruits who are already syphilitic when they come into the service do find their way into the military prisons. The syphilitic registers can throw no light on this possibility.

Furthermore, it must be admitted that the data on which this speculation is based is incomplete, since so many registers were lost or not available for these statistics. It is perhaps better to admit that the only conclusion that can be drawn from these figures is that syphilitics are leaving the service faster than fresh cases are being contracted in the service, and that deaths and discharges for disability are higher among syphilitics than among other enlisted men. These latter men often go to the Government Hospital for the Insane, to Fort Bayard, and to the Soldiers' Home, which undoubtedly helps to account for the high rates for syphilis in those institutions.

The very evident gaps in our knowledge of what becomes of syphilitics in the service emphasizes the necessity, which will be pointed out later, of identifying syphilitics when they enter the service and keeping them under observation, in order that we may have accurate information as to what becomes of these men and as to the extent of the financial burden their disabilities impose upon the Government.

PART IV.

CONCLUSIONS AND THE PRACTICAL CONSIDERATIONS SUGGESTED BY THIS STUDY.

SUMMARY AND CONCLUSIONS.

The results obtained in the preceding surveys are summarized in the following table for purposes of comparison:

Survey.	Total examined.	Known syphilitics.	++ Wassermann.	Undoubted syphilitics.	+ Wassermann.	Estimate of total number probably syphilitic.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Recruits	1,019	0	7.75	7.75	9.02	16.77
Cadets	621	0	2.57	2.57	2.89	5.46
White enlisted men	1,577	3.44	4.77	8.21	7.87	16.08
Colored enlisted men	1.472	1.08	21.80	22.21	13.11	36.00
Porto Rico Regiment	531	13.55	28.58	42.37	13.55	55.93
Military convicts	1,145	6.48	9.50	15.98	5.67	21.65
Insane soldiers	567	3.51	8.29	11.80	7.41	19.21
Tuberculous soldiers	229	7.56	15.72	23.28	15.72	39.00
Soldiers' Home [1]	1,171	11.62	13.40	25.02	9.73	34.75

[1] These figures do not include the results of the luetin examination.

The most important conclusions to be drawn from this work are briefly:

I. WITH REFERENCE TO THE MILITARY SERVICE.

1. A very large number of recruits, estimated at 16.77 per cent, are already syphilitic at the time they enter the service.

2. Since there are only 3.44 per cent of white enlisted men on the sick report for syphilis, it is certain that the majority of these syphilitic recruits never are diagnosed.

3. Many of these undiagnosed cases of syphilis are admitted to sick report under other diagnoses, and a certain but at present unknown amount of expense is thereby incurred by the Government.

4. From 2 to 5 per cent of the commissioned personnel of the Army are already infected with syphilis at the time they enter the service.

5. The percentage of syphilis among white enlisted men of the Army, estimated at 16.08 per cent, is slightly lower than the estimated percentage of infected accepted recruits.

6. Since there are about 3 per cent of fresh infections annually among these troops, it follows that syphilitics are leaving the service in some way faster than new cases are being acquired.

7. Study of the syphilitic registers of completed cases confirms this belief, because the rates for discharge for disability are twice as great for syphilitics as for all enlisted men.

8. Wassermann surveys of military prisoners, insane soldiers, tuberculous soldiers and inmates of the soldiers' home also confirm this belief, because they all indicate a prevalence of syphilis considerably higher than that obtaining among enlisted men.

9. Syphilis is much more common among negro troops than white troops and is acquired at a much earlier age in the case of negroes, so that it may be expected that a very large percentage of colored men are already syphilitic at the time they enter the service.

10. The highest rate for syphilis encountered in these surveys is among the soldiers of the Porto Rico regiment of Infantry.

11. About 13 per cent of the insanity in the service is directly attributable to syphilitic infection.

12. There is a distinct tendency in any group of men for syphilitic infections to accumulate with advancing years so that the older the group the higher the percentage of syphilis.

13. The percentage of syphilitic infections is lower among men in the Army than among similar men in civil life.

II. WITH REFERENCE TO THE CIVIL POPULATION.

1. We may estimate that about 20 per cent of the young adult male population of the class from which the Army is recruited are infected with syphilis.

2. We may estimate that about 5 per cent of the young men in our colleges are syphilitic.

3. This study confirms observations that have already been published indicating that syphilis is so prevalent among negroes that it is possibly the greatest single factor in the production of disability and high mortality rates among the race.

4. The high percentage of syphilis among Porto Rican soldiers indicates that syphilis may be one of the important causes of disability among native Porto Ricans.

5. Since syphilitic infection is so common, is productive of so much disability, and has so far entirely evaded sanitary control, it is believed that syphilis is a greater menace to the public health than any other single infectious disease, not even excepting tuberculosis.

THE PREVENTION OF SYPHILIS IN THE ARMY.

The main purpose of this bulletin was to investigate the prevalence of syphilis in the Army. However, this need not preclude a discussion of any sanitary measures that may correct the conditions found, and, indeed, any investigation which merely stops with a statement of the facts determined and makes no suggestion leading toward an improvement of conditions must be inconclusive.

The facts as brought out in the preceding papers indicate that syphilis is much more frequent among enlisted men of the Army than has generally been supposed. It might be assumed that since the diagnosis of syphilis is only made on approximately 3 per cent of all soldiers that the large number of cases of syphilis that remain undiagnosed are of no importance, so far as the Army is concerned, and could be ignored. But even if this assumption were correct we can not afford to take this attitude. When a man comes into the Army he sacrifices a large part of his personal liberty, and in return for that sacrifice it is a clear obligation on the part of the Army, and particularly on the part of the military surgeon, to provide the most enlightened and progressive medical treatment obtainable. To carry this to its logical conclusion means that all cases of syphilis should receive proper treatment.

Moreover, the civil community has long charged the Army with syphilizing its men and then returning them to civil life to infect civilians. The injustice of this attitude is apparent. For aside from the fact, demonstrated in the survey on recruits, that many more infections come into the service in the persons of men fresh from civil life than are acquired during military service, syphilis is never acquired in the Army. The individuals with whom the soldier comes in contact that infect him with syphilis are civilians, and the civil communities surrounding Army posts are responsible for permitting this traffic. The Army is, therefore, in no way responsible to the civil community for the syphilis that is acquired by the soldier. But since military control over soldiers is so far superior to any control that can be exercised over civilians, it is logical to expect much more of the Army in the prevention of infection and in the control and treatment of the cases of syphilis that do occur than is expected of the civil community.

Aside from these considerations, the assumption that these undiagnosed cases are of no importance to the Army is unwarranted. They are a constant potential source of new infections. Further, many of these undiagnosed cases of syphilis are actually on the sick report masquerading under such diagnoses as chronic muscular rheumatism, asteriosclerosis, myocarditis, aortic valvular lesions, neurasthenia, hypertrophy of the liver, nephritis, etc. In order to obtain some idea as to how frequent these unrecognized cases of syphilis might be, the Wassermann cards of 500 syphilitics taken at random were analyzed to determine the symptoms present at the time the Wassermann was requested. In the majority of cases the symptoms were clearly those of syphilis, but in many instances there was no indication of syphilis and the blood was evidently sent in simply as a routine, or in an endeavor to make a diagnosis by exclusion on symptoms not in themselves diagnostic. Eight per cent of the cases examined fell into this category. The diagnoses included acne, arteriosclerosis, chronic tonsillitis, insanity, rheumatic pains, cardiac dilatation, deafness, epilepsy, atrophic rhinitis, tinea circinata, retinitis, dizziness, tender joints, flat feet, lupus vulgaris, Riggs disease, tumor of the liver, furunculosis, chronic articular rheumatism, and general debility. Of course these particular diagnoses were revised as the result of the Wassermann findings before they were entered on the sick report; but the fact that such diagnoses can be made in cases of syphilis indicates clearly that there are many other similar cases in which the syphilitic cause is never detected. It is only comparatively recently that the importance of syphilis as a cause of many conditions has been recognized. Thus probably at least 90 per cent of all cases of aortic heart disease, and a large percentage of cases of myocarditis are actually syphilitic lesions. Yet syphilis of the heart has always been considered rather rare, and probably few of these cases are included as syphilis on the sick report. The same thing is true of many cases of gastritis. Up to a few years ago syphilis of the stomach was considered so rare as to be a curiosity, yet recent investigations have shown that it is not at all uncommon. Such examples might be multiplied with the inevitable conclusion that syphilis is even more protean in its manifestations than we have as yet realized. Because of this fact, if the incidence of syphilis in the service were markedly reduced, the sick report would probably be pared down out of all proportion to the reduction in the amount of syphilis actually shown in that report.

Such hitherto unrecognized cases of syphilis have added a great expense to the maintenance of the Army, the exact amount of which can not be calculated, because there is no way of determining the exact number of such cases, their ultimate end, or the extent to which the Government has been victimized in each case. Some idea of the magnitude of the cost of these unrecognized cases of syphilis may be derived from the following generalized considerations:

1. The Government necessarily pays for their maintenance and treatment in hospital. Since the real cause of their infirmity remains

unknown, they do not receive specific treatment, and consequently remain on sick report a long time.

2. During this period they continue to draw their pay, which would be stopped in most cases if the true nature of the disease were known.

3. They increase the total noneffective strength of the Army, and all overhead charges for the Army are the same for noneffectives as for effectives.

4. They are frequently discharged on certificates of disability, thus entailing a financial loss to the Government. No adequate return is secured in such cases for the money spent on their maintenance, military education, and transportation.

5. They frequently secure a pensionable status, and thus become a financial burden for many years.

6. Many are sent to the Government Hospital for the Insane, where they become a charge on the Government for maintenance and treatment all the rest of their lives. Capt. King's Report on Mental Disease and Defect in the United States Troops, Bulletin No. 5, Office of the Surgeon General, states that during one year 77 enlisted men, 4 officers, and 7 general prisoners, or a total of 89, were admitted to the Government Hospital for the Insane directly from the service or from military prisons. It has been pretty conclusively shown that in at least 13 per cent of the insane soldiers at this institution the insanity is directly attributable to syphilis. Applying this to the Army cases it will be seen that each year the Army sends approximately 11 men to the Government Hospital for the Insane because of paresis or cerebral syphilis. In practically all of such cases the syphilitic infection was of long standing and was not recognized prior to the development of mental symptoms.

7. The survey made on the inmates of the Soldiers' Home shows that many more such cases are maintained in such institutions. It must not be supposed that we are assuming that all the large number of cases in whom the existence of a syphilitic infection was detected were actually disabled because of syphilis; but all medical officers who have served at the Home will agree that there are very many such cases.

8. A certain number of officers are retired "in line of duty" for conditions that are in reality due to syphilis. Thus only recently an officer was retired in this way for locomotor ataxia, a condition now universally admitted to be a manifestation of syphilis.

Now, while it is probable that under no method of administration or sanitary regulation can all of these unrecognized cases be detected or all of this great burden of expense be removed, yet it is equally certain that these cases, with their resultant expense to the Government, can be greatly reduced in number. At present post surgeons only request a Wassermann reaction on cases that in their judgment may be syphilitic or in whom the diagnosis is not plain. This diagnostic use of the Wassermann reaction should be greatly extended, and it is believed that if a Wassermann test were made of all patients that remain on the sick report more than five days that most of these at present undiagnosed cases of syphilis would be detected. Many hospitals have for years made a routine examination of urine of all patients. Perhaps one case in a thousand has sugar in the urine. The percentage of albumen found is, of course, higher. But if it is worth while to carry out this routine examination of the urine for the sake of the occasional case in which the information so obtained is of value to the attending physician, of how much more value would be a routine Wassermann on all patients. This is not done in many civil hospitals because few of them possess the facilities for performing this reaction. The medical department of the Army has a great advantage in this respect, since its laboratories are already performing this test, and it will be a great improvement when a routine Wassermann reaction is performed on all patients. No changes are necessary in order to commence this practice, which could be directed by a circular to medical officers.

Regulations aiming at the prevention of venereal diseases have been in force in the Army for several years and have accomplished a certain amount of good. Confining our attention to syphilis, there is no doubt that the disease may be prevented by the early application of calomel ointment. As the Surgeon General has stated in his report for 1914, the method of venereal prophylaxis is fairly well crystallized and therefore is much the same in each command. The results appear to be in proportion to the earnestness and intelligence of the commanding officers and the surgeons intrusted with carrying out the orders on this subject. It is evident that these regulations are capable of effecting even more in the way of the prevention of syphilis as surgeons and commanding officers become more impressed with the desirability and necessity of enforcing these regulations. But this matter has been so thoroughly worked out, and is so completely in the hands of the above-mentioned officers, that no further discussion of this matter is desirable in this bulletin.

It should, however, be perfectly clear that such measures are aimed solely at the prevention of the approximately 3 per cent of cases of syphilis that develop during military service, and that no methods of dealing with the approximately 16 per cent of cases of syphilis introduced into the service in the persons of recruits have yet been formulated. Yet, since a fresh case of syphilis can hardly remain unknown in this day of venereal inspections, it becomes clear that practically all of these unrecognized cases of syphilis referred to above as causing the Government so much expense are not contracted in the service, but are part of the 16 per cent brought into the service by recruits.

It is a question, therefore, in the light of the information furnished by this investigation, if further measures should not be taken at the present time to further reduce the amount of syphilis in the Army. A discussion of such measures may be divided into the following heads:

1. The rejection of all syphilitic recruits, including those having a positive Wassermann.
2. The enlistment of syphilitic recruits who manifest no physical signs of the disease but who will be known as syphilitics when they enter the service and will be required to take treatment.
3. Standard treatment for all cases.

I. The Rejection of All Syphilitic Recruits.

Strictly speaking, this would be very difficult, but a real endeavor to carry out this policy would result in the exclusion of the great majority of syphilitic recruits who are at present enlisted. At the present time many known syphilitics are enlisted provided that they show no physical manifestations of the disease at the time they are examined. It is believed that this policy is very costly to the Goverentment and that all such men should be rejected. This would involve no change in the present method of recruiting except the issue of a circular to all officers charged with recruiting directing that no men known to have had syphilis should be accepted.

But it is also believed that this is not sufficient, and that the time has come when a Wassermann reaction should be made on all recruits, and those found syphilitic by this test should also be excluded. This process of exclusion might be carried out at recruit depots or at recruiting stations, and the method employed in carrying out this test may be briefly discussed.

1. *Rejection at recruit depots.*—At each recruit depot a medical officer and one Hospital Corps man would be detailed and equipped to perform the Wassermann reaction. This test would then be performed on all recruits who had in other respects passed the physical examination. The reaction should be performed daily, with the exception of Sunday, and under these circumstances if the bloods were taken in the morning the report could be in by 4 or 5 o'clock of the same afternoon, thus causing no delay. All applicants for enlistment having a double plus Wassermann reaction should be rejected. There should, however, be a provision that this, like any other defect, could be waived by the Secretary of War in the case of exceptionally desirable men otherwise qualified for the service.

Such men, however, would enter the service provided with a syphilitic register, would receive treatment, and could not secure a pensionable status as the result of conditions obviously syphilitic.

The question naturally arises, What shall we do with those men who have acquired syphilis during a previous enlistment and wish to reenlist? If the man can present convincing evidence that he has been cured as the result of treatment received in the service, he might be accepted. This will apply to comparatively few cases. With this exception, it appears that unless a man is a noncommissioned officer or is otherwise a very exceptional man that the best rule would be to exclude such men on exactly the same terms as men applying for a first enlistment. The longer a syphilitic remains in the service the greater is the chance that he may develop locomotor ataxia, paresis, or some disability by which he may secure a pensionable status in some way.

A duplicate card record should be kept of each man examined, one to be retained at the recruit depot and one to be mailed to the Surgeon General. The records so collected from the different recruit depots would in the course of a few years afford a more complete index as to the prevalence of syphilis in the United States than has ever been obtained or could be obtained in any other manner.

By the adoption of this plan the great majority of those already infected with syphilis would be excluded from the service, and we have already shown the advantages to be derived from such a procedure, and may pass to the objections that may be urged against it. The immediate and only serious objection to be raised against this plan is that it will necessarily increase the cost of recruiting the Army, because return transportation must be paid to the place of acceptance on the possible 10 to 15 per cent of recruits rejected at recruit depots for this cause. This objection is very serious yet it need not necessarily prove insuperable. The cost of recruiting is not the only thing to be considered in this connection. It is obvious that if we spend $10 in recruiting each man, but secure men who are worth $1,000 to the Government, we save money as compared with a system that only spends $5 in recruiting each man, but secures men worth only $800. It is believed that the amount of money saved to the Government by adopting this procedure will greatly exceed the increased sum to be expended in recruiting. But as the amount to be saved is vague and distant, and as the increased sum to be expended on recruiting is definite and immediate, the natural tendency is to refuse to appropriate money for this purpose. The American people have always preferred a policy involving billions in pensions in the future to one involving millions for preparedness in the present.

2. *Rejection at recruiting stations.*—If this plan is rejected, we may pass to the second, in accordance with which a blood specimen for the Wassermann reaction could be taken in a Wright capsule from all men that have been accepted by the recruiting officer and mailed to the nearest laboratory for the test, a report to be telegraphed as promptly as possible to the recruiting officer. Only those men passing this test as well as the other present requirements will be sent to the recruit depots. In order to accomplish this it will be necessary for the recruiting officer to keep otherwise acceptable applicants for from 24 to 48 hours while waiting the report on the Wassermann. It will be only exceptionally that men will have to be held longer than this time, for with laboratories at all recruit depots, in addition to the four department laboratories in the United States, specimens may be sent by mail from almost any point to the nearest laboratory within 24 hours. In accordance with this plan some expense is necessarily entailed in telegraphing and for the subsistence of applicants held to await the report from the laboratory. It is probable, however, that in spite of this the overhead expense of recruiting will be actually diminished by this method, since there will certainly be fewer rejections at recruit depots on whom return transportation must be paid. This is now a heavy charge against the present recruiting system, since about 14 per cent of the men accepted by recruiting officers are rejected at the recruit depots. (Report A. G., 1913.) It should also be noted that venereal diseases caused the greatest number of these rejections in 1911 and 1912, though these diseases were only third as a cause for rejection in 1913. (Report S. G., 1914, p. 191.) During 1913 heart disease headed the list as a cause for rejection.

Disease of the heart muscle is frequently due to syphilis, while of valvular lesions, almost all cases of "causeless" aortic disease, particularly in men between 20 and 40 years of age, are due to syphilitic aortitis and have a positive Wassermann. Cabot (J. A. M. A., 1914, LXIII, 1461) has recently classified 600 cases of heart disease according to the pathologic process responsible for the disease. Of these 600 cases, 74, or 12.3 per cent, were due to syphilis. But of 294 of these cases in males, 52, or 17.7 per cent, were due to syphilis. It is clear that syphilis is in reality responsible for a considerable part of the cases rejected for so-called heart disease.

With regard to venereal diseases, since gonorrhea and chancroids are generally easily detected, and develop promptly after exposure it is fair to assume that the majority of the rejections for venereal disease were in reality due to syphilis. Heart disease and venereal disease combined account for 206.38 per thousand, or a little more than a fifth of all the rejections at recruit depots. Probably one-half of this, or one-tenth of the total rejections, are caused by syphilis under these two heads alone. Many of those rejected at recruit depots for other causes such as physical debility, diseases of the circulatory system, diseases of the nervous system, underweight, etc., were probably also syphilitic. It is believed therefore that it is a conservative estimate that a tenth of the total number of rejections at recruit depots which for 1913 would have been 495 men can be saved by having a preliminary Wassermann test at recruiting stations, and the rejection of all applicants who have a positive Wassermann. This means that the return railroad fare of these 495 men would be saved as an offset to the cost of telegraphing and of rationing applicants while awaiting the report. The cost of recruiting would be little if at all increased by this method, and the Government would effect the large saving already pointed out as the result of the exclusion of syphilitics.

Another possible objection to this plan consists in the fact that the collection of blood specimens will necessarily be in the hands of enlisted men attached to the recruiting stations, instead of in the hands of medical officers as would be the case if the specimens were collected at recruit depots as described under heading (1). This is not a serious matter, however. There is absolutely no danger attached to taking a blood specimen in a Wright tube from the ear, and thousands of such specimens have been taken by Hospital Corps men. Satisfactory specimens are difficult to take by this method if it is not performed correctly, and very easy to take when the correct technique is followed. I feel confident that in an hour any enlisted man of average intelligence can be taught to take a proper blood specimen. If this plan were followed, it would be, of course, necessary to instruct the men at recruiting stations as to the proper method of taking specimens, as otherwise there would be much time lost because of the impossibility of performing the test on the specimen sent and the necessity of asking for others. This is merely a matter of detail that can be worked out.

A further objection which may be urged against either of the propositions outlined above is that fact that they possibly entail the rejection of about 15 per cent of all recruits that are accepted under present methods of enlistment. There have been times when it has been difficult to obtain a sufficient number of desirable men under the present requirements, and this plan would, of course, increase this difficulty considerably. This objection, like the others, is real but not insuperable, for under ordinary circumstances there is seldom any difficulty about obtaining a sufficiency of men. During some years and at certain seasons of each year the main difficulty is to keep them out. But when there is a real shortage of men, such as in war times or during seasons of unusual prosperity, what is the first thing to be done? The physical requirements are lowered. Men are taken in with defective vision, under weight, under height, defective teeth, etc. If there is a shortage of men, the requirements should be lowered first in the least important things. Which is most important, that a man should have perfect vision, 20/20, or that he should be free from syphilis? Sixty-four inches is our minimum requirement for height. Is it more desirable to exclude men of 62 inches height and otherwise eligible or to exclude syphilis? It seems to me that the interests of the Government would be better subserved by lowering the requirements in many respects before we knowingly accept syphilitics. The syphilitics are by far the poorer risk. It is of course admitted that in time of actual war, when large numbers of men must be enlisted and trained, any such plan to exclude syphilitics would go by the board, but at such a time all other physical requirements go also. The point that it is desired to make is that it is quite as important to exclude syphilis as most of the other physical defects that are at present a bar to enlistment.

3. *Rejection of syphilitic applicants for a commission.*—All the arguments that apply to the rejection of syphilitic recruits have even greater force with regard to applicants for a commission. Enlisted men, as a rule, serve only one or two enlistments, but the commissioned officer generally remains in the Army permanently. The manifestations of syphilis that cause permanent disability, such as aneurism, locomotor ataxia, and paresis, are almost always late developments, occurring usually in men over 40, who have already spent many years in the service. The result is that there is a natural tendency to retire such cases "in line of duty." These cases cause much trouble in the service in other ways too numerous to mention. For example, several years ago an officer was tried and convicted for unnatural sexual practices and other irregularities. Within a few months of his conviction he died of syphilitic disease of the brain. Such irregularities are common symptoms of paresis, and there can be little doubt that this officer should have been sent to an insane asylum instead of being tried. The frequency with which officers are convicted of duplicating pay accounts and other financial irregularities, the idiocy of which are incomprehensible to a normal mind, leads to the conviction that some of these officers may be suffering from the "delusions of grandeur" of early paresis. One can never predict at what time such symptoms may appear in a syphilitic. Dr. William A. White, superintendent of the Government Hospital for the Insane, has stated in an address that a syphilitic officer should never be allowed to command a battleship. Is the responsibility of a general in the field less than that of the commander of a battleship?

Further, the objections that apply with regard to the rejection of syphilitic recruits for enlistment do not apply in the case of applicants for a commission. It will be a matter of little difficulty to have a Wassermann test made on all cadets shortly before they are commissioned, and this test can easily be made a part of the physical examination of all other candidates for a commission. As a general rule, the men of the class who apply for a commission do not suffer from syphilis in as high a percentage as is the case in the class of men who apply for enlistment. Rejections on this account need not be very numerous, but the ones that do occur will become a matter of great importance to the Government in protecting it from the imposition of having syphilitics carried on the retired list.

II. The Enlistment of Syphilitic Recruits Who Manifest no Physical Signs of the Disease.

In case it is deemed inadvisable for any reason to follow either of the plans outlined above to exclude syphilitics, it is still possible to diagnose such cases when they enter the service. This again necessitates the performance of the Wassermann reaction at all recruit depots in the manner already described. Instead, however, of rejecting all applicants having a double-plus or plus Wassermann, such men would be accepted, providing they manifest no obvious physical signs of the disease and were otherwise acceptable. A syphilitic register would be filled out for these men at the recruit depot and mailed to the surgeon at the post to which the recruit was assigned. Instructions should be issued to all medical officers that such cases should be kept under observation, exactly as is the case with fresh infections of syphilis, and should receive active treatment sufficient in amount to at least hold the disease in check and to prevent the appearance of these cases on the sick report for syphilis. In case the man was transferred the register should, of course, be sent to the surgeon at the new station. If this procedure was followed in the case of all syphilitic recruits, in a few years the unrecognized cases of syphilis would almost entirely disappear, for we have already pointed out that since fresh cases either present themselves for treatment in the natural way or are detected at venereal inspections, practically all of these unrecognized cases exist prior to enlistment. As a result of this examination these cases would be recognized from the first, and should never be permitted to escape observation.

Therefore, if this system was officially adopted—and at present writing there is good reason to believe that it will be—all cases of syphilis in the Army should be under observation and treatment. The Government will benefit in exactly the same particulars as would be the case were syphilitics excluded, but to a lesser degree; that is, the sick report would be lower than is the case at present, but not so low as would be the case were all syphilitics excluded. There would be fewer pensions for syphilitic conditions, but more than would be the case were syphilitics excluded, etc. The reason for this is plain. If syphilitics are excluded, that is the end of the matter, so far as the Army is concerned; if they are admitted, they become subject to a more or less complicated system of observation and treatment which may break down at a number of points in some cases. It is always possible that such cases may escape observation through carelessness on the part of some officer through the loss of registers, because they are erroneously considered cured, and in other ways. It is also possible that they may receive an amount of treatment insufficient to prevent the development of the disease, which would be followed by an appearance on sick report that would, of course, have been impossible had the man originally been excluded from the service. It is by no means easy to gauge the exact amount of treatment to be given such cases, and there would always be a tendency to cut the amount down because of the expense, the trouble of giving it, and because the man himself would tire of it and attempt to escape it. All of these difficulties would be more apt to appear in the field, where it must be admitted any such system of observation and treatment would probably break down. If the syphilitics were excluded at the start, this trouble would be avoided in the field, and there would be a more efficient Army. There is much evidence to show that soldiers having syphilis are more apt to break down under the stress of active service than would have been the case had they remained at a post in time of peace. There is good reason for believing that paresis is more apt to occur under such unusual physical strains.

Further, the saving to the Government outlined above would be partly offset by the cost of treatment. Large sums are being expended at present for salvarsan as well as other drugs and apparatus for the treatment of syphilitics, when only about 3 per cent of the enlisted strength of the Army is receiving this treatment. If these surveys are correct in indicating that about 16 per cent of the men in the service are syphilitic, and if all of these cases were identified and treated, the cost of such treatment would be almost exactly five times the amount expended at present.

However, if this method is adopted there would be no increased cost in recruiting except such as would be borne by the medical department for the performance of the Wassermann. The end result would undoubtedly be a considerable saving to the Government, and as the result of the information obtained by performing the Wassermann on all recruits, it is probable that it will become possible later to adopt the plan of total exclusion of all syphilitics. Full and complete information is necessary upon which to base any action in the administration of the Army. There is practically no accurate information at present available as to how much disability and cost to the Government is actually caused by syphilis. It is obviously a function of the medical department to procure this information, and the examination of all recruits for syphilis, particularly by the Wassermann, will go far toward affording this information. If the facts so obtained bear out those published in this bulletin, the day is not far distant when syphilitics will be excluded from the service.

COST OF PERFORMING THE WASSERMANN REACTION ON ALL RECRUITS.

Since the adoption of this examination is being seriously considered it will be well to determine the cost to the Medical Department. One medical officer with one assistant, when properly trained and supplied with the proper equipment, can easily perform 100 tests daily, except Sunday, making 600 tests a week. During the 52 weeks of the year they would, therefore, be capable of performing 31,200 tests, or, allowing two weeks for vacation, 30,000 tests. If a laboratory for the Wassermann is established at each of the five recruit depots, each laboratory with a capacity of 30,000 tests a year, facilities would be provided for a single test on 150,000 men. Between 25,000 to 30,000 recruits are accepted annually. It will be seen, therefore, that all of the men at present being accepted could be examined by five such laboratories and many of them reexamined to confirm the diagnosis in doubtful cases without the slightest strain on the working capacity of these laboratories. Indeed, the laboratories would continue to be capable of performing this work should the size of the Army be doubled. The itemized cost of each laboratory may be stated as follows:

I. (1) Salary of one captain, Medical Corps, 5 years' service	$2,640
(2) Salary of one sergeant, Hospital Corps, at $42 per month	504
(3) 600 guinea pigs, at $0.50 (reduced if fewer tests are made or if guinea pigs are raised)	300
(4) 30 rabbits, at $1 per rabbit	30
(5) Other materials (requisitions for breakage in test tubes, pipettes, etc.)	200
Total	3,674
II. Permanent equipment, as described later, not to exceed	600

All of the items of expense allowed here are amply sufficient and could be reduced in certain instances; but, estimating the cost of a single laboratory at $4,000 in round numbers, the five laboratories would cost $20,000 a year at most. It must be pointed out, however, that approximately three-fourths of this expense is in salaries that are already being paid, so that the actual cost in materials will be at most about $600 for each laboratory annually, or a total of $3,000. This is a much fairer way to estimate the cost, for at each of these depots a medical officer is usually detailed for laboratory work which takes at least a part of his time.

It is probable that the man detailed to perform the Wassermanns can also perform this routine laboratory work. This depends upon the number of Wassermanns that must be performed, but since one man has a capacity of 30,000 tests annually, and since it is improbable that with the present size of the Army any one laboratory will have that number of tests to perform, there should be a certain amount of spare time that could be devoted to other laboratory work.

III. Standard Treatment for all Cases of Syphilis.

At present there is a very great diversity in the methods employed by different medical officers in the treatment of syphilis. It might be supposed that this diversity is caused by endeavoring to fit the treatment to the individual needs of the patients, but this is a minor factor and causes quantitative rather than qualitative changes in the treatment. All syphilitics need mercury, but there is a great variety in the methods by which this remedy may be used. Medical officers become accustomed to using one method or preparation and frequently use the same preparation on all their cases, but naturally vary the dosage to suit the requirement of the individual patient. Since each patient is different, we shall never be able to standardize rigidly treatment and dosage in this or any other disease, but, obviously, certain methods of treatment are superior to others, and many medical officers to-day are using inferior methods. This statement is based on the treatment reported in hundreds of cases. Now, if some methods are inferior and others are markedly superior, it should be possible to choose the better methods and require their general use in the service. It is clear that if, following the examination of recruits, there is to be a great increase in the number of cases of syphilis that are to be under observation and treatment, there should be some general consensus of opinion as to what we wish to accomplish by this treatment and as to the methods to be used in attaining this end.

1. *The purpose to be attained.*—In the first place, are we to aim at the permanent cure of these cases, or are we to aim to simply give sufficient treatment to render them noninfectious and keep them off the sick report? The answer to this question depends partly upon the length of time the disease has lasted. Experience has shown that when properly treated permanent cures can be obtained in the majority of primary and early secondary cases, but that cure is only rarely obtained in late secondary and tertiary cases. These latter cases will be the most numerous class to be treated, since the majority will have been infected before entering the service. They would

not have been enlisted had they shown signs of active secondary syphilis, so that we may assume that they will almost all belong to the late secondary or early tertiary period, when there is little hope of effecting a radical cure. If these cases are in good general health, to what extent shall they be treated? In view of the fact that permanent cures will be produced in but few of these cases, judged by our past experience in which the number of cured cases is woefully small in comparison to the number actually treated, would it not be preferable to attempt to give only sufficient treatment to keep the patient well and off the sick report? Would not this latter policy save considerable expense? This question, which at first appears rather important, is in reality largely theoretical. In the first place, most of these patients will come to treatment because they have a positive Wassermann. In the second place, it is generally accepted, except by a few reactionaries, that we must be guided by the Wassermann reaction in the treatment of all cases of syphilis, and that if the Wassermann becomes positive after a course of treatment it is an indication for further treatment. If this indication is neglected, in many cases there will be a clinical relapse, and we will have the patient on sick report with some condition that could have been avoided had treatment been given when the Wassermann first became positive. Since these relapses are the very thing that we wish to avoid in all cases, and since we can never tell which particular cases will develop syphilitic lesions if the Wassermann is neglected, it follows that the only practical procedure is to treat all patients so long as they have a positive Wassermann. This is not only the one practical method to adopt in order to secure those advantages that will accrue as the result of keeping all syphilitics well, but it is in line with our duty to the patient which unquestionably demands that we give him the best treatment possible. If we do this in the late secondary and tertiary cases, we can let the question of cure take care of itself.

The question is different, however, in the primary and early secondary cases. Since there is ample evidence to show that these cases can be cured, if we are failing to cure them at present in our service it is because of failure to use the proper method of treatment.

2. *What method of treatment should be adopted?*—Medical officers have always been required to send all treatment given since the last Wassermann reaction was made when making requests for reexaminations. It was originally supposed that by comparing these treatments with the result effected in the Wassermann reaction the efficacy of various forms of treatment could be accurately determined. This hope has been blasted, because in thousands of records there are hardly two cases in which the Wassermann reaction has been ob-

served for a sufficient length of time that have received the same treatment. This means that if any exact knowledge as to the value of different methods of treatment is to be obtained, some further steps must be taken to secure this information. The difficulty at present is that there has been too great variety in the treatment used by different medical officers. But during this time considerable work has been done by various investigators, and as a result of the information so obtained it should be possible to adopt for experimental purposes a standard method of treating primary syphilis, for example. At present possibly one medical officer will use 2 injections of neosalvarsan and 15 hypodermic injections of mercury salicylate, while another may use 4 injections of salvarsan and a course of 50 mercurial inunctions. If the former treatment is too little, we lose cures, whereas if the latter treatment is more than is necessary the Government is expending money on salvarsan unnecessarily. Obviously, there is a best method to follow in treating this condition, but we will never find it out so long as every medical officer treats his cases differently, because no one man has a sufficient number of cases of primary syphilis on which to base conclusions. This is obviously a condition that requires organized research, which may be obtained by adopting an official standard treatment for primary syphilis. A beginning has already been made along this line in Circular No. 14, August 3, 1914, from the Office of the Surgeon General. But, as already pointed out, no very valuable evidence is being secured at present owing to the fact that there is too much latitude allowed in the amount and kind of treatment. The Army offers exceptional advantages for determining the value of different methods of treating syphilis, because the total number of such patients is large, and most of them are kept under continuous observation for three years, an impossibility in civil practice. Moreover, repeated Wassermann reactions may be performed as often as desired without any expense to the patient or physician. Such facilities for observation may be obtained nowhere so well as in the Army. If research along this line were properly organized, we might expect to determine definitely the best course of treatment for the radical cure of both primary and early secondary syphilis, the best and most effective methods of administering mercury and salvarsan, and to obtain an answer to many questions at present unanswerable connected with the treatment of syphilis. Such information would not only be of scientific value, but would be of the greatest practical importance to the Army, enabling medical officers to secure control of cases of syphilis by the most efficient and economical method.

THE STANDARDIZATION OF THE WASSERMANN REACTION FOR USE IN THE MILITARY SERVICE.

In the past no attempt has been made to standardize the Wassermann reaction, so that all the different service laboratories would be using the same test. As a result several different kinds of Wassermann reactions have been performed in the various department laboratories according to the particular idiosyncrasies of the individual officers in charge of these laboratories. The laboratories at the Army Medical School, the Leavenworth department laboratory, and the department laboratory at Fort Sam Houston, Tex., have all used about the same system, namely, that described by Capt. Craig, Medical Corps, in Bulletin No. 3, loc. cit. The laboratories at San Francisco and Manila have always used a sheep hæmolytic system, sometimes with controls to eliminate natural antisheep ambocepter in the sera tested, and sometimes without such controls. Moreover, there has been no uniformity in the different laboratories in the kind of antigen used. Simple alcoholic extract of guinea-pig heart, the acetone insoluble faction of Noguchi, alcoholic extract of syphilitic fœtal liver, and cholesterinized extracts have all been used at different times in the various laboratories.

The natural result of such variations has been that no comparison was possible between the work of the various laboratories. A man in one department with a double plus Wassermann would become negative as soon as he was transferred to another department and his blood was tested in another laboratory or vice versa. This has naturally tended to throw some discredit upon the value of the reaction. There have been several opportunities to determine how wide this variation may be. Thus in the case of a man strongly suspected of being syphilitic one of the department laboratories could not get higher than a plus reaction. The blood was sent to the laboratory of the Army Medical School, where a double-plus reaction was obtained. The surgeon in charge at this department laboratory then sent me some of his antigen, and his antigen was compared with the heart cholesterin antigen as indicated by the following titrations:

0.1 c. c. suspected syphilitic serum used in all tubes.

	Amount of antigen used.			
	1.5 c. c.	*1 c. c.*	*0.5 c. c.*	*0.025 c. c.*
Antigen (laboratory Army Medical School)	++	++	++	+
Antigen (department laboratory)	+	+	+−	−

0.1 c. c. antigen used in all tubes.

	Amount of serum used.			
	1 c. c.	*0.75 c. c.*	*0.50 c. c.*	*0.25 c. c.*
Antigen (laboratory Army Medical School)	++	++	++	+
Antigen (department laboratory)	+	+	−	−

It is quite evident from this that many cases giving a double plus reaction at the Army Medical School will vary between a plus and a negative reaction at this particular department laboratory.

Still more important is the fact that no systematic endeavor to study the results of the treatment of syphilis in the Army can be of great value until all Wassermann reactions are performed in the same manner. For, in following the syphilitic registers of cases having received a certain treatment, but having had their Wassermann reactions performed at different laboratories, no comparison is possible. It should be possible in the Army to determine the best method of treating syphilis, since the patients are under control and observation during the entire period of their enlistment. Thus a certain fixed treatment could be outlined which would be followed exactly on all syphilitics by a certain number of posts. Another treatment could be carried out systematically on all syphilitics at certain other posts. At the end of a few years we would then be in a position to state definitely as the result of this experience what should be adopted as a standard treatment of syphilis in the Army. But before this could be done it is essential that all Wassermann reactions in the service should be made according to the same technique and should be strictly comparable.

Further, it has been recommended that the Wassermann reaction be performed on all recruits, and this will entail the establishment of new laboratories for the performance of the Wassermann reaction. It is particularly desirable that the reaction performed in these recruits should in all cases be the same and that the results of the different laboratories established at recruit depots should be strictly comparable. For all these reasons, it has been thought desirable to attempt at this time the standardization of the Wassermann reaction for military service.

This subject of standardization may be considered under two heads:

I. The compulsory use of the same reaction in all laboratories.

II. A standard equipment for this work to be supplied to all laboratories.

I. The Compulsory Use of the Same Reaction in All Laboratories.

1. *The system to be adopted.*—If the recommendations of the writer are followed, the reaction to be adopted will be that described by Capt. Craig in Bulletin No. 3, Office of the Surgeon General, with certain slight modifications; in other words, the system in use in this laboratory at present.

It will be unnecessary to describe this reaction further here because of the full description of the technique given in Bulletin No. 3, and it is only necessary to mention the modifications. These consist of:

(1) The use of a 0.4 per cent cholesterinized human heart alcoholic extract, prepared as follows: A normal human heart is obtained from a recent autopsy, this is washed free from blood and all fat is carefully removed. The heart muscle is then minced by running through a meat grinder, and to each 100 grams of this minced heart muscle 1,000 c. c. of absolute alcohol are added. The whole mixture is then placed in bottles in a shaking machine and shaken continuously for 24 hours, at the end of which time extraction is completed. The alcoholic extract is filtered off and kept in well-stoppered bottles in an ice chest. The extract so prepared and kept appears to retain its properties unimpaired for a long time. From time to time small quantities, such as 25 c. c., are removed from this stock and cholesterin is added in such proportion as to render the resultant solution 0.4 per cent cholesterin. If cholesterin is added to the whole volume of the extract it does not keep nearly so well and is apparently more apt to become anticomplementary. After the cholesterin is thoroughly dissolved, the antigen is again filtered and stored in the ice box. The antigen is then titrated with positive and negative sera, and to determine its anticomplementary limits.

(2) The use of measured quantities of blood serum to be tested instead of the four drops from a capillary pipette. It has been found that drops from a capillary pipette actually vary considerably in size, even when the end of the pipettes are of the same diameter. The size of the drop under these circumstances depends upon the viscosity of the serum, which varies considerably in different patients. It was, therefore, thought desirable to abandon the use of capillary pipettes and use standard 1 c. c. pipettes graduated in tenths and hundredths. One-tenth of a c. c. of serum to be tested is measured into the front tube, for the actual test, and from 1 c. c. to 2 c. c., depending upon the amount of serum furnished, is measured into the back tube for the anticomplementary control. This has necessitated the adoption of different methods of collecting blood specimens, since sufficient serum (0.3 c. c.) was rarely sent in the Wright capsule, nor was it easy to withdraw serum from a Wright capsule into a graduated pipette.

For all of these reasons a new method of collecting blood which will be described later, is recommended.

2. *Advantages to be gained by the adoption of this system by all service laboratories.*—There are a number of reasons for urging the universal adoption of this system, which may be stated briefly as follows:

(1) It is at present in use in 4 out of 6 of the department laboratories, and therefore the adoption of this system will cause the least amount of change in existing practice.

(2) It is believed that this system is unquestionably as accurate and efficient as any other system. It has also been demonstrated that two men working independently can secure identical results when using this system. An evidence of this may be seen by comparing the two sets of figures obtained by Capt. Craig and myself in the survey of prisoners at Fort Leavenworth.

(3) It is the most convenient system in that it eliminates the necessity of keeping sheep and also the necessity for making controls to detect the presence of natural antisheep amboceptor in the sera tested.

(4) It is very economical in the use of materials such as amboceptor, antigen, and complement. This fact results not only in the saving of time and money, but it affords the possibility of performing a large number of tests with the same amboceptor and antigen. This further tends to standardize the reaction.

No two antigens or amboceptors act exactly in the same manner. and therefore the use of the same reagents over as long a period as possible is desirable in order that the results obtained should be comparable. In this connection it may be noted that the same antigen was used in practically all of the tests performed in the course of this survey work.

(5) Amboceptor paper, as used in these tests, keeps practically indefinitely and may be made up months in advance. A considerable stock may thus be kept on hand, and the laboratory worker should never be troubled with any shortage in amboceptor. This eliminates one very disagreeable feature, perpetual shortage of amboceptor, which has been experienced by many Wassermann workers.

(6) The antigen recommended, an alcoholic extract of human heart, fortified with 0.4 per cent cholesterin, has been found to be most efficient and reliable, and is the nearest approach to a standard antigen obtainable at present; it is, moreover, obtainable with great ease in large quantities.

(7) It has been found by actual experience that the most important reagents for use in the Wassermann, namely, the amboceptor paper

and the antigen, can be sent by mail to distant points, and may there be used by workers who do not happen to have the facilities for preparing these reagents. Thus amboceptor and antigen were supplied by mail to Maj. Russell, Medical Corps, at Vera Cruz, Mexico, and Maj. Russell was thus able to perform the Wassermann reaction in the field laboratory for the troops serving at Vera Cruz. It is believed that this is the first time that the Wassermann reaction has ever been done at a field laboratory.

The facilities for preparing these reagents at the Army Medical School Laboratory are superior to those at most other laboratories. The experience related above suggests that it might be desirable to prepare amboceptor and antigen at this laboratory in quantities sufficient to supply the other department laboratories. This would simplify the work for the laboratories having the least facilities, and would also tend to further standardize the reaction. Even if this should not be desirable or feasible, it is believed that this plan should be followed in the case of the new laboratories whose establishment is contemplated at recruit depots for the performance of the Wassermann on recruits, and that amboceptor and antigen should be supplied these laboratories from the Army Medical School. The officers in charge of these laboratories will have their hands full in taking blood specimens and in actually performing the reactions, without the additional trouble of preparing their own reagents, and in addition, if this suggestion is adopted, an advantage will be secured in that all of these recruit depots will be performing the reaction with the same materials.

3. *Possible objections to the compulsory use of the same reaction in all laboratories.*—(1) The adoption of any particular technique "by order" might be resented by certain workers using a different system, who might regard this as an infringement on their scientific liberties.

However, this is not a serious objection. The manifest advantages accruing to the service from the adoption of a uniform system should be sufficient inducement to the laboratory worker to forego opposition to such a procedure. In any case, in the military service procedures become standardized as soon as there is a sufficient body of evidence to justify the procedure. Thus methods of diagnosis in typhoid and antityphoid inoculation have become standardized in the military service, to the great advancement of the interests of the service.

(2) Such a standard system, however, should not be so inelastic as to be impervious to real improvements. The technique of the Wassermann reaction has been continuously subject to modifications, some of which have been improvements, and there is no reason to suppose that further improvement will never be made in the future.

If the reaction is to be kept standardized it will not be possible for individual workers to adopt such improvements on their own initiative. But any worker who believes he has found such a desirable improvement can call attention to it by publication or by letter to the Surgeon General, and if it is generally approved this improved technique can be adopted simultaneously by all laboratories in accordance with a circular which may be issued by the Surgeon General describing and directing such change.

II. A Standard Equipment for the Wassermann Reaction.

1. *The collection of blood specimens.*—In the past specimens have been collected in Wright capsules and mailed to the laboratory. The Wright capsule had many advantages which justified its adoption for routine use in the service, but experience has demonstrated that it also possesses certain disadvantages, which may be briefly enumerated as follows:

(1) It can only be filled with a sufficient quantity of blood by rigid adherence to a certain technique. If this technique is modified in any way, the specimen is worthless.

To anyone who has acquired this technique it seems amazing that so much difficulty is experienced by others in securing proper specimens; yet approximately 10 per cent of the specimens arriving at this laboratory must be rejected because they either contain an insufficient amount of blood, or have been hæmolysed through burning the blood at the time the tube is sealed, or through breakage in transit or in centrifuging because the tube has been improperly sealed.

(2) Even when the specimen has been properly collected, a further percentage becomes spoiled in transit. This is due to the fact that the mechanical shaking in the mail is sufficient in some cases to hæmolyse the red cells, so that the serum becomes too deeply stained with the dissolved hæmoglobin to permit of an accurate reading of the Wassermann. A further percentage of specimens becomes anticomplementary during transit. These difficulties are most marked in the case of posts situated at a considerable distance from the laboratory and when for any reason there has been any delay in the mail service.

(3) Under the best circumstances the Wright capsule when filled with blood rarely contains 0.3 c. c. blood serum, and when the tube contains unclotted blood it is impossible to fill a graduated pipette from the Wright tube. As a result, the serum has been taken from the Wright tube with a capillary pipette and 4 drops of serum used in both front and back tubes in the test. While it is not believed that this drop method has led to any serious inaccuracies. yet it is obviously more scientific to use an accurately measured quantity of serum in each test.

The constant loss of specimens entails extra work at the post and in the laboratory, and must be exceedingly annoying to everyone, from the patient who has to be bled twice, to the laboratory worker, the clerk who mails the reports, and back to the surgeon, who is disappointed at receiving word that the specimen "leaked" or was "hæmolysed" when he is expecting a report on a case. In addition to being annoying, delay in receiving the report on the Wassermann may frequently be a serious matter in a case in which treatment should be given promptly. For all of these reasons it has been thought desirable to devise some other method of sending blood specimens which would have the advantages of the Wright capsule without the above disadvantages.

The method about to be described was worked out in collaboration with Maj. B. H. Dutcher, Medical Corps. When survey work from Porto Rico was first started it was found that specimens collected in Wright capsules were absolutely worthless by the time they arrived at this laboratory. I suggested sending serum alone, but Maj. Dutcher stated that it was very difficult to fill a Wright capsule with serum, and suggested a tube about the same size as a Wright capsule, closed at one end and drawn out at the other end, but left open to permit the introduction of a hypodermic needle. A number of such tubes were made and sent to Maj. Dutcher at San Juan, P. R., and thereafter nothing but perfect specimens were received from him, containing an ample sufficiency of clear serum. None of them were anticomplementary, and the fact that perfect specimens can be sent from this distance demonstrates the practicability of the method.

These tubes are made of soft glass tubing, having an inside diameter of one-fourth of an inch, and when completed are about 3½ inches long. (See fig. 1.) These tubes are made at the laboratory of the Army Medical School and will be supplied on requisition.

Blood may be collected from a vein by any method the surgeon prefers. Probably the simplest method is to introduce a large-caliber hypodermic needle into the vein, permitting the blood to drip into a sterile test tube or centrifuge tube. The blood may be withdrawn with a sterile syringe and transferred to a sterile centrifuge tube. The Keidel vacuum tube gives excellent results, but its cost prohibits its extensive use in the military service.

A satisfactory and rapid method of obtaining blood from a vein is afforded through the use of the Macrae needle, which is made by Tiemann, New York. This device consists of a rubber stopper, through which pass a straight needle and a curved tube. The rubber stopper with the needle is sterilized by boiling and placed in any small sterile test tube which fits the stopper snugly. A piece of thick rubber tubing which is furnished with the device is then attached to the curved tube where it projects from the stopper and

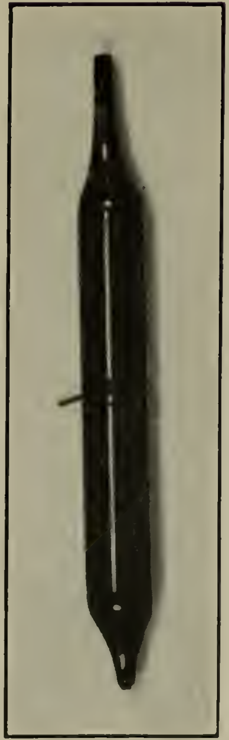

FIG. 1.—CAPSULE FOR SERUM.

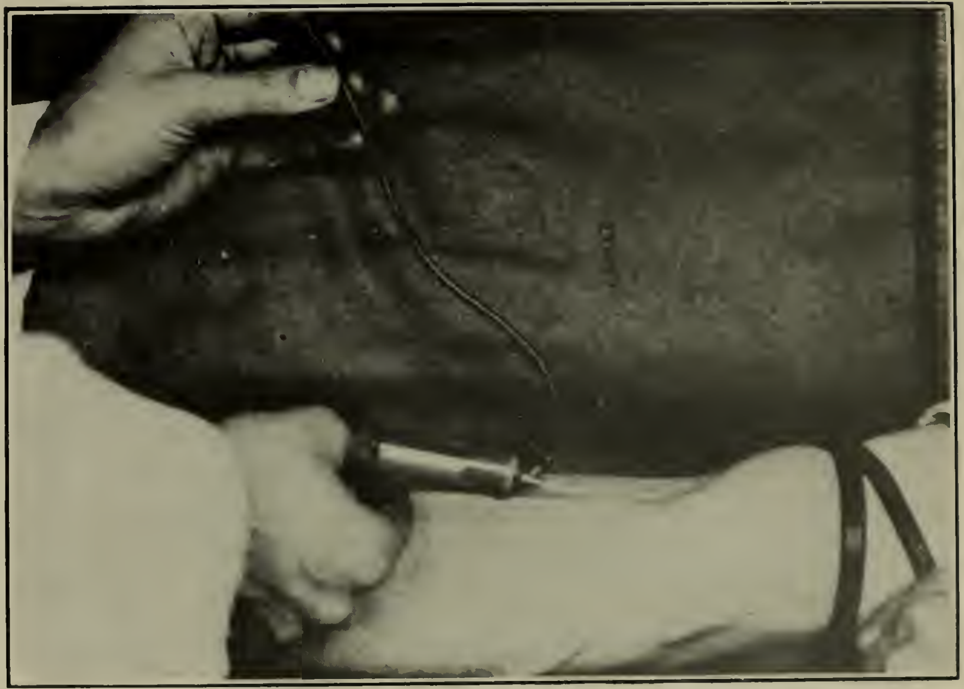

FIG. 2.—METHOD OF OBTAINING BLOOD WITH MACRAE NEEDLE.

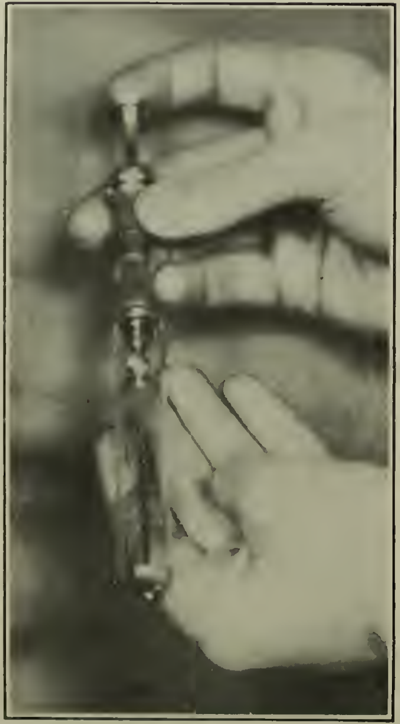

FIG. 3.—WITHDRAWING SERUM FROM CLOT.

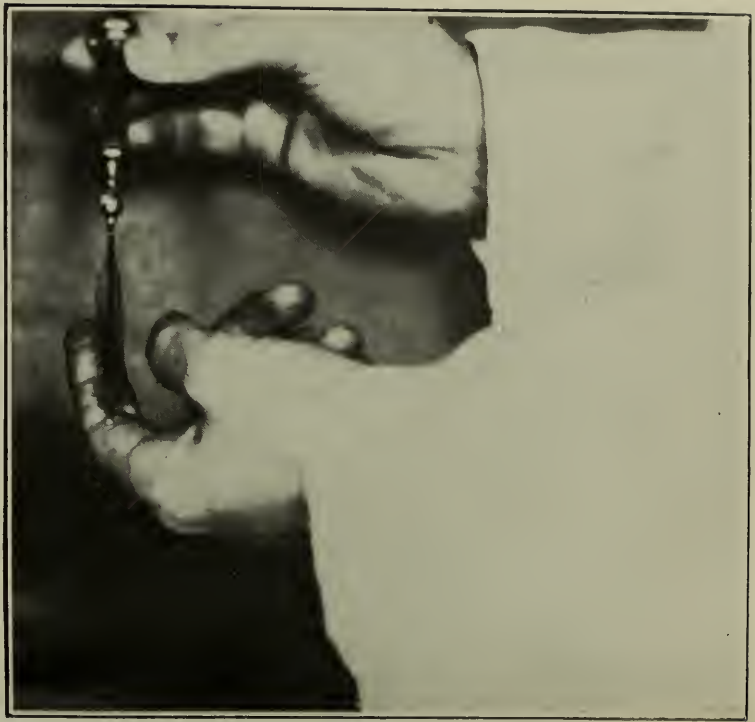

FIG. 4.—FILLING CAPSULE WITH SERUM.

the apparatus is ready to use. The patient's arm is sterilized by iodine, a tourniquet is passed about the upper arm, and the patient is directed to open and close his fist several times. As soon as the veins fill and stand out clearly the needle is thrust into the vein and suction applied to the rubber tube. The vacuum thus produced causes the blood to spurt into the tube in a steady stream, so that several cubic centimeters of blood can be collected in a few seconds. The needle is withdrawn and the puncture sealed with collodion. (See fig. 2.)

When a considerable number of bloods are to be taken three or four of these needles may be used. As each case is completed an assistant takes the needle and stopper, cleanses it of blood, and drops it in a convenient boiler and hands the operator a freshly boiled needle for the next case. By keeping several needles constantly boiling and using them in sequence no time is lost, and no more than a minute or two need be given to each case, so that a large number of specimens may be taken in a short time. As these needles, if properly cared for, can be used indefinitely, the cost of this procedure is trifling. The retail price of these needles is $1.75.

However the blood be taken, the tube containing it is properly labeled and *should stand at room temperature for one or two hours.* This is important, for blood clots much more readily at room temperature. Frequently it will be found if tubes containing freshly drawn blood are placed in the ice box at once the blood clot adheres to the walls of the tube, and no serum can be obtained without loosening the clot. This injures the blood cells, and often results in a hæmolysed serum. If the blood be left at room temperature, plenty of serum can usually be withdrawn at the end of one hour. If separation of serum has not been rapid enough, this may be hastened by placing the tube in a centrifuge and shaking the clot down. The process is materially facilitated by collecting the blood originally in a centrifuge tube, or at least a small test tube which may be fitted into the centrifuge, in order to avoid the necessity for transferring any blood specimens into a different tube at this stage of the procedure.

As soon as the serum has separated from the clot it is withdrawn by means of a Record syringe and a needle that has been specially made for this purpose by the Kny-Scheerer Co., New York. This needle is of large bore, so that it will not readily become clogged, fits the Record syringe, is 4 inches long, and when attached to the syringe the point of the needle easily reaches the bottom of a centrifuge tube. This syringe is filled with clear serum, as shown in figure 3.

The needle is then introduced into the modified Wright capsule described above and the serum is expelled from the syringe until the tube is three-fourths full, taking care not to soil the end of the tube with serum. (See fig. 4.)

The end of the tube is then sealed in the flame of a bunsen burner or alcohol lamp, labeled, and is ready to be packed for the mail.

When the tube arrives at the laboratory, labeled with the patient's name, it is given a serial number, and number, name, and post from which received are entered in a blank book kept for this purpose. After having been entered in this way, the specimen throughout its further course in the various steps of the Wassermann reaction is identified only by its number.

As soon as numbered the specimens are placed serially in the compartments of a wooden tray shown in figure 6. This tray can be made by any carpenter and contains a double row of compartments, each 2 inches square. These compartments are numbered from 1 to 10. The specimens numbered from 1 to 10 are placed in the first compartment; from 11 to 20 in the second, etc. One such tray will, therefore, hold 100 specimens. When a larger number of specimens must be handled, two such trays may be used, the compartments in the second tray being numbered from 11 to 20. It is a great advantage to keep the specimens together in their proper sequence in this manner, since when the tests are set up, each rack (fig. 9) contains space for 10 specimens, the ones numbered from 1 to 10 going in the first rack.

Since only serum is sent in the tubes described (fig. 1), the necessity for centrifuging the specimens is obviated and they are now ready for inactivation. Serum is inactivated by being kept at a constant temperature of 56° C. for one-half hour. Various kinds of apparatus have been devised for this purpose, but in this laboratory the following equipment has been found to be most satisfactory. The specimens are taken from the tray and placed in a specially constructed paraffin bath, which is kept in a Freas electric incubator set at 56° C. This incubator, with the bath inside, is shown in figure 5.

THE FREAS ELECTRIC INCUBATOR.

This incubator is catalogued as No. B. 5025 by Eimer and Amend, New York. Its inside dimensions are 12 by 12 by 12 inches, and the retail price is $85.50. The advantages of this incubator are that it will maintain a constant temperature of 56° C. without any troublesome manipulations. It is heated and regulated automatically by electricity, and is therefore available in posts having electricity but not gas, and the fire risk is eliminated.

Water is not required, so that there can be no leakage. No auxiliary devices are needed. To operate it is only necessary to attach it to a lamp socket and turn on the current. It burns very little elec-

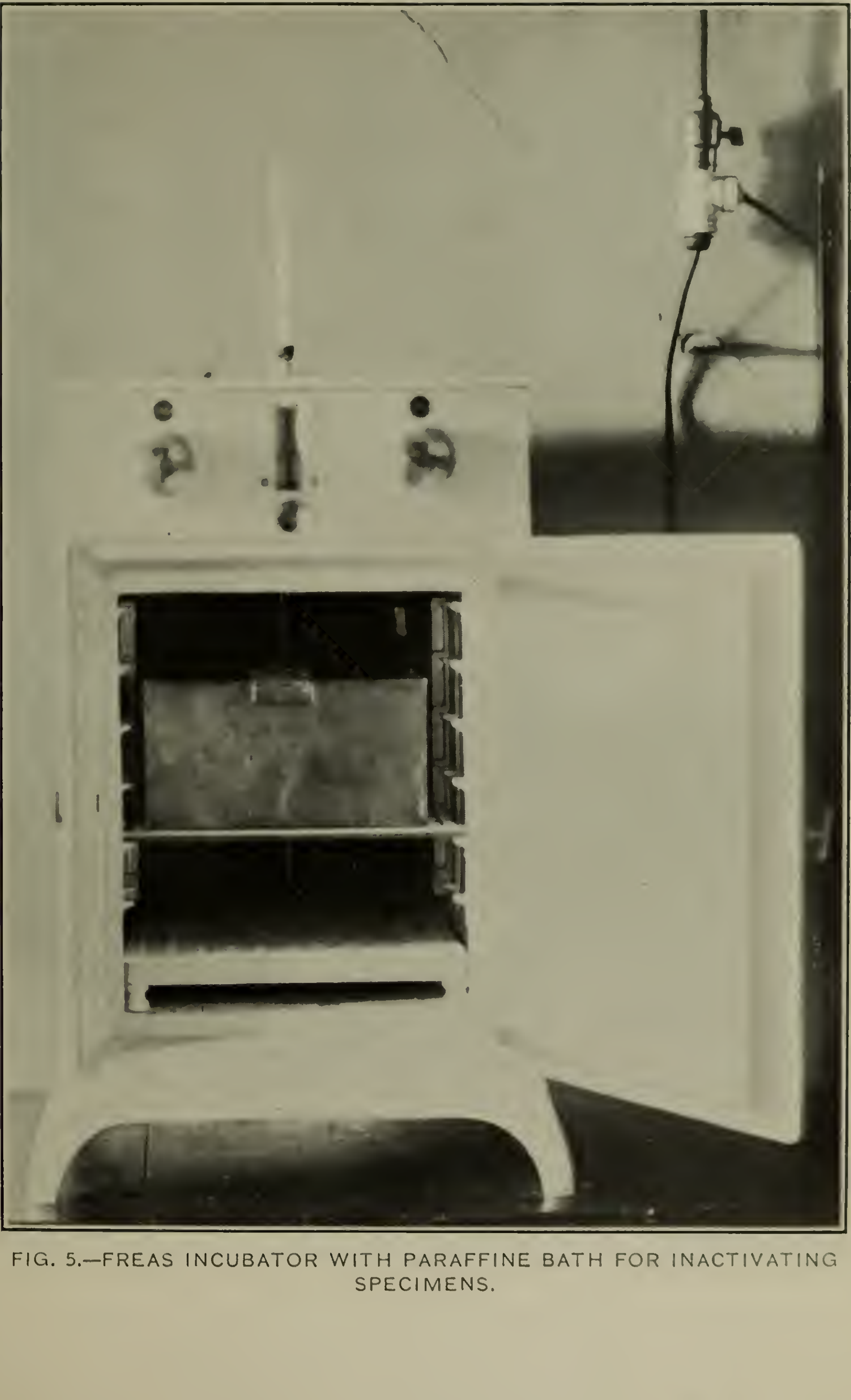

FIG. 5.—FREAS INCUBATOR WITH PARAFFINE BATH FOR INACTIVATING SPECIMENS.

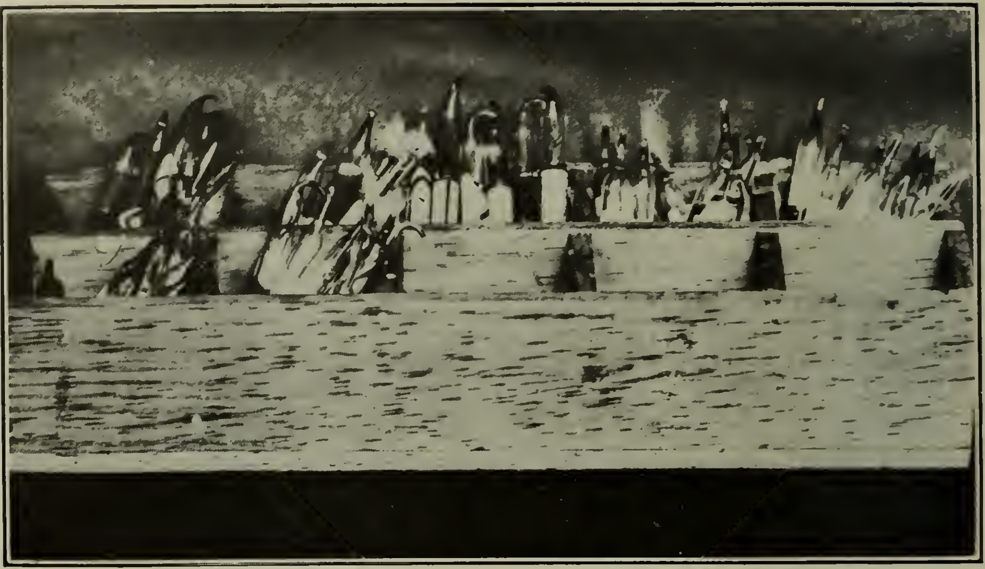

FIG. 6.—TRAY FOR SPECIMENS.

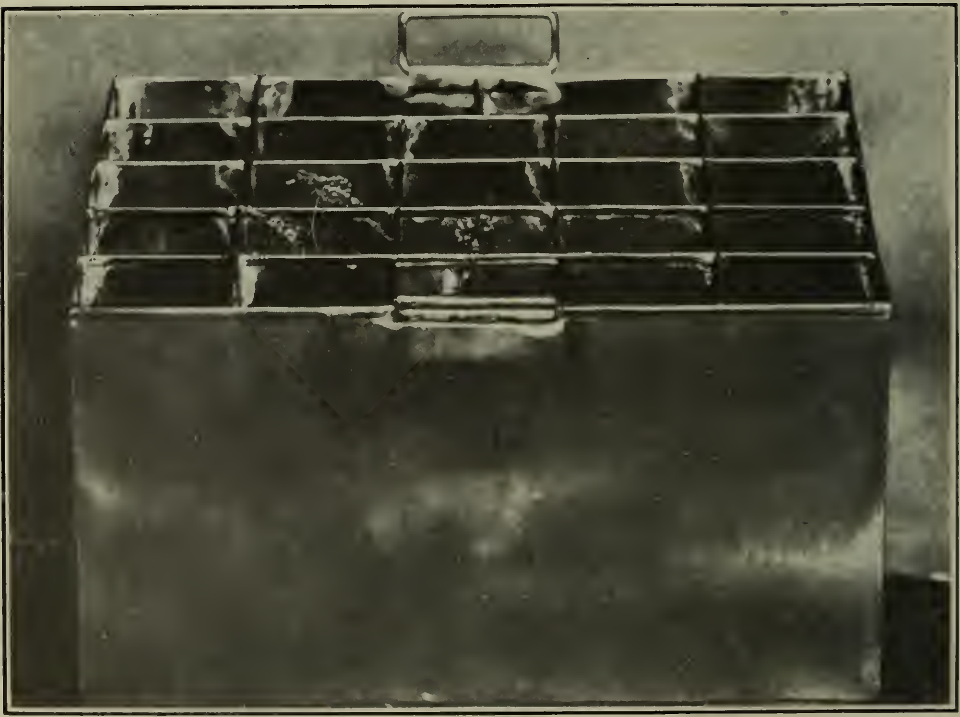

FIG. 7.—PARAFFINE BATH FOR INACTIVATING SPECIMENS.

tricity, because it is so constructed that there is little loss of heat, and after it is once heated only sufficient current is used to maintain this temperature. Finally, it is a permanent piece of apparatus which with ordinarily careful handling should remain serviceable indefinitely.

PARAFFIN BATH.

The bath shown in figure 7 was constructed of sheet copper by Topham, Washington, D. C., in accordance with specifications furnished by the writer, and can be duplicated for $15. Its dimensions are 10 by 10 by 3½ inches deep. It contains 21 compartments each 2 inches square and 2 compartments 2 by 4 inches square. These compartments all communicate at the bottom, so that the paraffin with which the bath is filled can flow readily from one compartment to another, and thus maintain a constant temperature and the same level in all compartments. Each small compartment is designed to receive 10 tubes (fig. 1) of serum. The two larger compartments are designed to hold larger tubes or ampules which are occasionally received. It will be seen that the bath is large enough to inactivate 250 specimens at once, which is the largest number of tests that has been handled in one day in this laboratory. It possesses the great advantage that the specimens can be kept in order, thus saving much time that would otherwise be spent in sorting specimens. Thus the tubes numbered from 1 to 10 from compartment 1 of the tray (fig. 6) would be placed in the first compartment of the paraffin bath, the tubes numbered from 11 to 20 from compartment 2 of the tray in the second compartment of the paraffin bath, and so on. A thermometer is kept constantly in the bath to guard against variations in temperature.

PARAFFIN.

Paraffin of a melting point of 43° C. is used in sufficient quantity to keep the bath about three-fourths full; i. e., to completely cover the serum in the specimen tube. Paraffin of higher melting points can be used but is undesirable because it solidifies on the specimen tubes too rapidly as they are removed from the bath. Water can also be used in the bath, but paraffin is distinctly preferable. It happens not infrequently that the glass tubes containing specimens become cracked or leak because of imperfect sealing. If water were used in the bath, the leakage of water into the specimen would render the specimen unfit for use. On the other hand, when paraffin is used in the bath it is immaterial even if paraffin does leak into the specimen, for it does not mix with the serum and hardens as soon as the specimens are removed from the bath. This paraffin can be purchased at a rate of 15 cents per pound, and about 10 pounds are required to fill the bath. It is used over and over again, so that only small amounts are required from time to time to make up for losses and to keep the bath at the proper level.

After the specimens have been inactivated in this paraffin bath for half an hour the bath is removed from the incubator and the specimens are quickly taken from the bath. Each tube as it is removed from the bath is wiped with a piece of cotton or gauze to remove the excess paraffin and is replaced in the proper compartment of the tray previously described (fig. 6).

THE BLOCK FOR BREAKING SPECIMEN TUBES.

The specimen tubes are sealed at both ends and must be opened before the serum can be pipetted off. This is done by scratching the tube deeply with a file or hardened steel knife at a point slightly above the level of the serum and breaking off the tip of the tube by a smart blow with the wooden handle of the file or knife. The tube almost invariably breaks cleanly at the point scratched. This operation was originally performed by resting the tube on the edge of the table at which the Wassermann work is done. It was, however, a noisy operation and disfigured the table. A block for this purpose was therefore devised (fig. 8). This is a simple wooden block with a beveled edge, reinforced with a piece of sheet lead. The bottom of the block is covered with a sheet of corrugated rubber. The rubber prevents the block from slipping about on the table, and both the rubber and the lead deaden the sound so that it is barely perceptible. The lead forms a better bed upon which to rest the tube when it is struck than is afforded by the wood alone.

Around the edge of the block is fastened a rack with four compartments. This is quite a convenient place to arrange the specimens upon which the operator is working, but is not an essential part of the block.

THE WASSERMANN RACK.

There are several Wassermann racks on the market, but none of them have been satisfactory to the writer for various reasons, and they are expensive ($2.50 apiece). The following rack (fig. 9) was made by Topham, of Washington, D. C., in accordance with specifications furnished by the writer, at a price of $1 apiece. It is made throughout of copper of such weight as to be strong and durable. Each rack contains 10 pairs of holes, for 10 tests, and the corresponding anticomplementary controls, and is constructed so that it is impossible for a tube to fall out, no matter how hard the rack is shaken. At each end of the rack is a handle through which the fingers may be slipped, and two racks may be carried at once with one hand by placing them end to end and lifting them by the two middle handles. Each pair of tubes is numbered from 1 to 10 by stamping

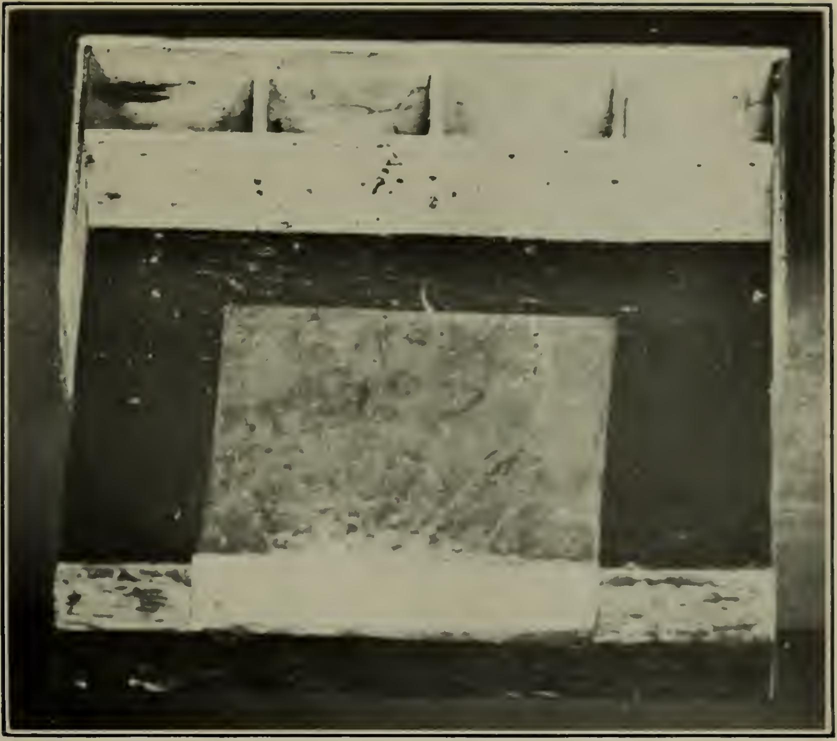

FIG. 8.—BLOCK FOR BREAKING CAPSULES.

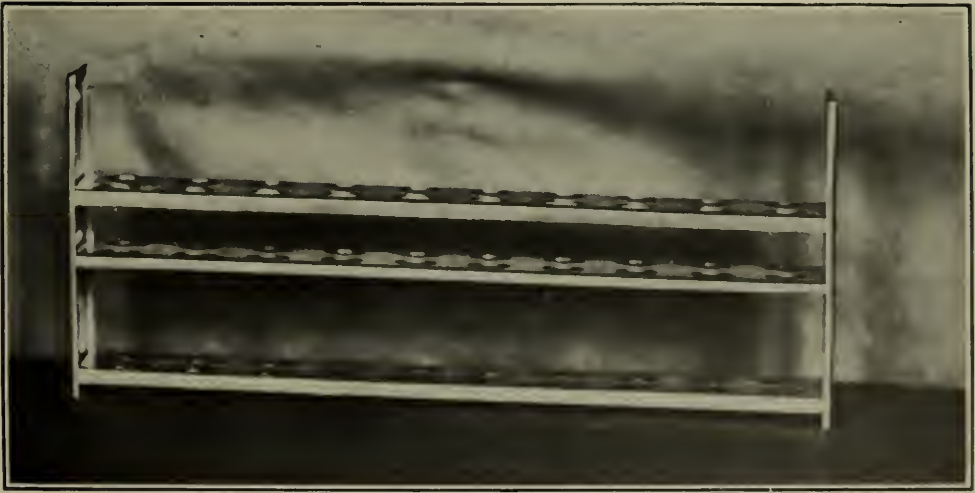

FIG. 9.—WASSERMANN RACK.

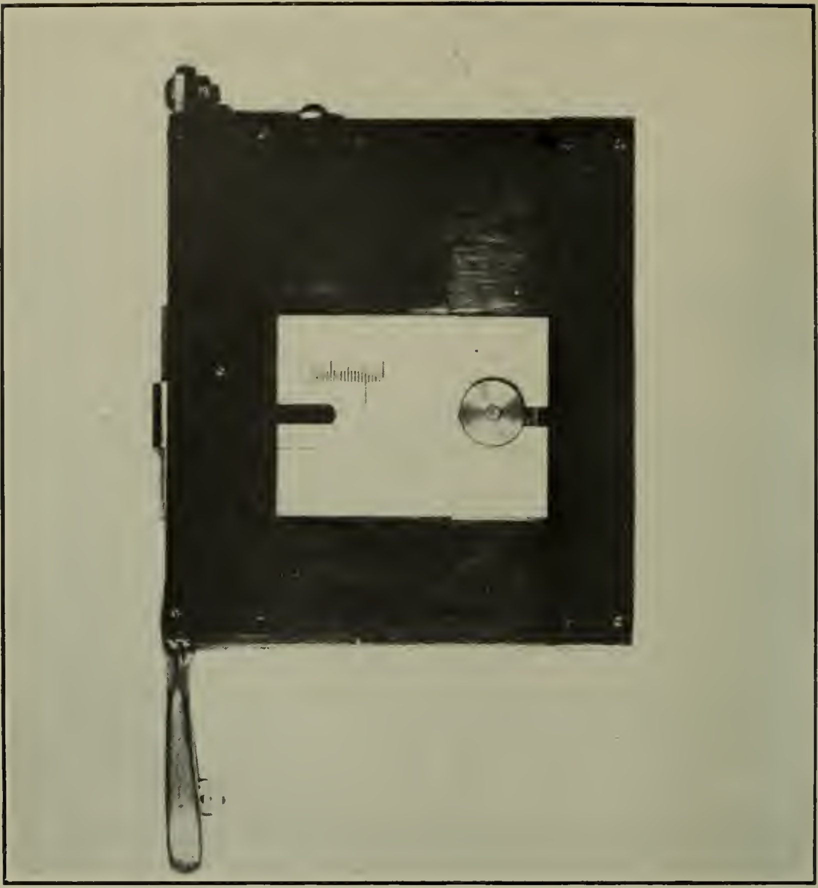

FIG. 10.—AMBOCEPTOR CUTTER. BACK VIEW SHOWING SCALE AND SET SCREW.

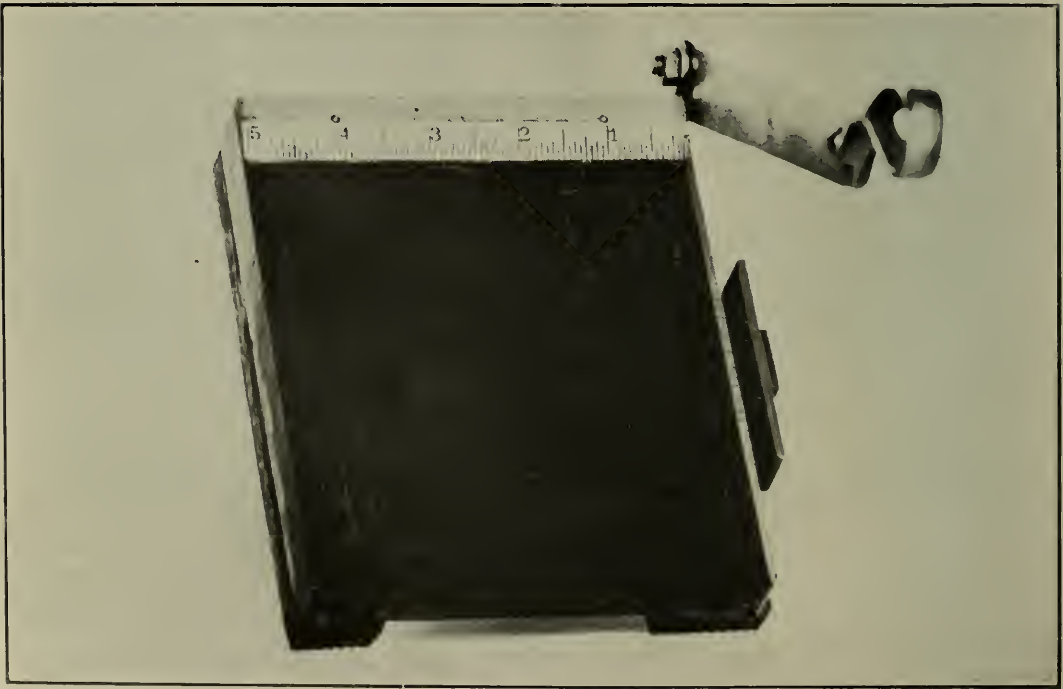

FIG. 11.—AMBOCEPTOR CUTTER. FRONT VIEW SHOWING GAUGE.

the appropriate number into the copper between each pair of holes. Twenty such racks are used in a set, and each rack is numbered from 1 to 20 by stamping the number in the left-hand corner of the top copper cross piece. By this means every tube is numbered serially, and each specimen from 1 to 200 may be placed in its appropriate tube. Thus specimen No. 9 would be placed in tube 9, rack 1. Specimen No. 19 would be placed in tube 9, rack 2. Specimen 29 would be placed in tube 9, rack 3. Specimen No. 34 would be placed in tube 4, rack 4. Specimen 40 would be placed in tube 10, rack 4, etc. The use of racks containing 10 tests is a great advantage, since it is almost impossible to confuse specimens when they are numbered serially and each placed in a correspondingly numbered tube. In order to maintain this numbering, when for any reason a specimen is spoiled or rejected, it becomes necessary to remove the tubes corresponding to the number of the specimen.

SETTING UP THE TESTS.

The tubes are all filled with the proper amount of salt solution (0.9 c. c.) and placed in the racks (fig. 9), which are arranged in numerical sequence before the operator. If a considerable number of tests are to be performed, much valuable time is saved by working with an assistant. The assistant sits at the table at the left side of the operator, with the tray containing the specimens (fig. 6) and the block (fig. 8) in front of him. The assistant then takes the specimens in their proper numerical sequence and, breaking the capsules, hands them to the operator. The operator inserts a graduated pipette and withdraws sufficient serum (0.3 c. c.) and pipettes off one-tenth of a cubic centimeter into the anterior tube corresponding to the number of the test and two-tenths of a cubic centimeter into the posterior tube for the anticomplementary control. When the sera of all the tests have been placed in the proper tubes, complement and antigen are added. Two special long 1 cubic centimeter pipettes graduated in tenths and hundredths are used for this operation. A preliminary titration of the complement, which is invariably made, usually shows that the unit of complement is 0.05 cubic centimeter. Since two units are used in each test, one-tenth of a cubic centimeter is required in each tube, and, therefore, all 20 tubes contained in the rack will receive their quota of complement from two loads of the pipette. One-tenth of a cubic centimeter of antigen is always used in the front tubes. One pipette full of antigen is, therefore, exactly sufficient for the 10 tests in each rack. As each rack is completed, it is pushed aside over a glass table top to the assistant, who shakes it. It will be seen from this description that there are practically no false movements or time lost looking for specimens. The operation has been systematized, so that when assistant and operator have been trained, 200 tests can be easily set up in little over an hour. The racks are then placed in a water bath for one-half hour for the fixation of the complement.

MEASURING THE AMBOCEPTOR.

While waiting for the fixation of the complement the amboceptor is measured. Sheets of amboceptor paper are used. Each sheet is 8 centimeters square and has been impregnated with the amboceptor serum and dried (see p. 75, bulletin No. 3). This paper was originally measured and cut by hand, which was quite a laborious process. In order to facilitate this step an amboceptor cutter and markers were devised. Supposing that the unit of the particular amboceptor is a piece 5 by 5 millimeters. The dial on the back of the amboceptor cutter (fig. 10) is set at 5 millimeters. This sets the gauge on the cutter (fig. 11, front view) at exactly 5 millimeters from the cutting edge of the board. The cutter is, in fact, simply a photographic trimming board with this device attached, which enables us to cut amboceptor paper of any width from 1 to 15 millimeters. The paper is simply placed squarely on the board and its edge advanced until it is even with the gauge, and the knife is brought down. As many strips as are required may thus be cut in a few seconds, and the width of the pieces so cut will be more accurate than if they were cut by hand.

The strips so cut are marked by the markers shown in figure 12. The markers consist of two brass plates, which are grooved at set distances for the reception of steel needles, and the two plates with the needles between are held rigidly in position by means of screws. Three such markers are used. In one the needles are set 4 millimeters apart; in the second the needles are 5 millimeters apart, and in the third they are 6 millimeters apart.

The strips of paper are held together on a piece of cork and the needles pressed firmly through all the pieces of paper, as shown in figure 12. The paper is then removed from the needles and each strip is perforated with holes at 5 millimeters apart (supposing the 5-millimeter marker was used).

When the tests are removed from the bath it is a matter of only 10 minutes to pass from tube to tube with a small sharp pair of scissors and drop a piece of paper exactly 5 by 5 mm. into each tube by cutting squarely on the holes marked in each strip of paper, after which the blood suspension is added and the tests are ready to incubate.

It will be seen that between the three sets of markers and the varying width of strips that can be cut (from 1 mm. to 15 mm.) it is an easy matter to obtain accurately measured pieces of paper of a

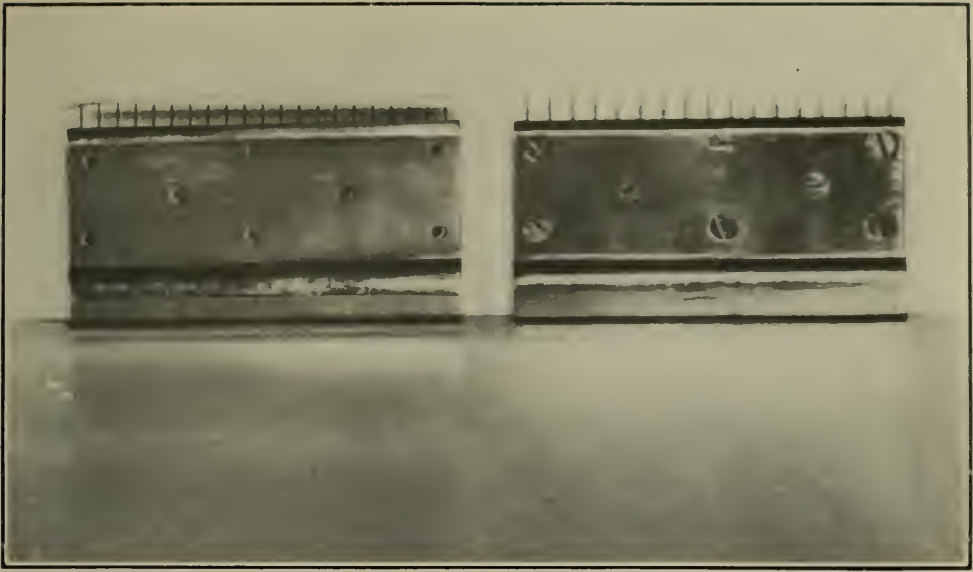

FIG. 12.—AMBOCEPTOR MARKERS.

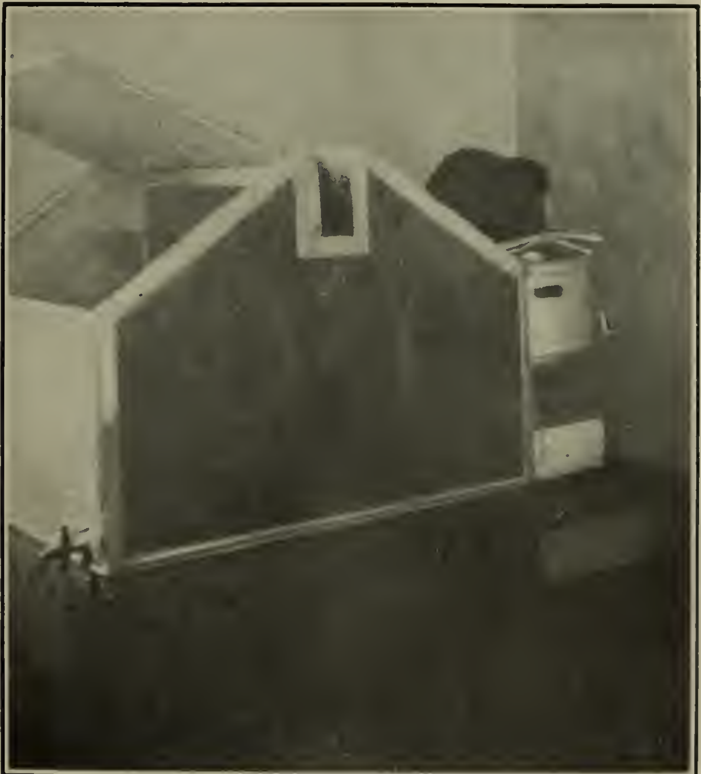

FIG. 13.—BATH USED FOR INCUBATION OF WASSERMANN REACTIONS.

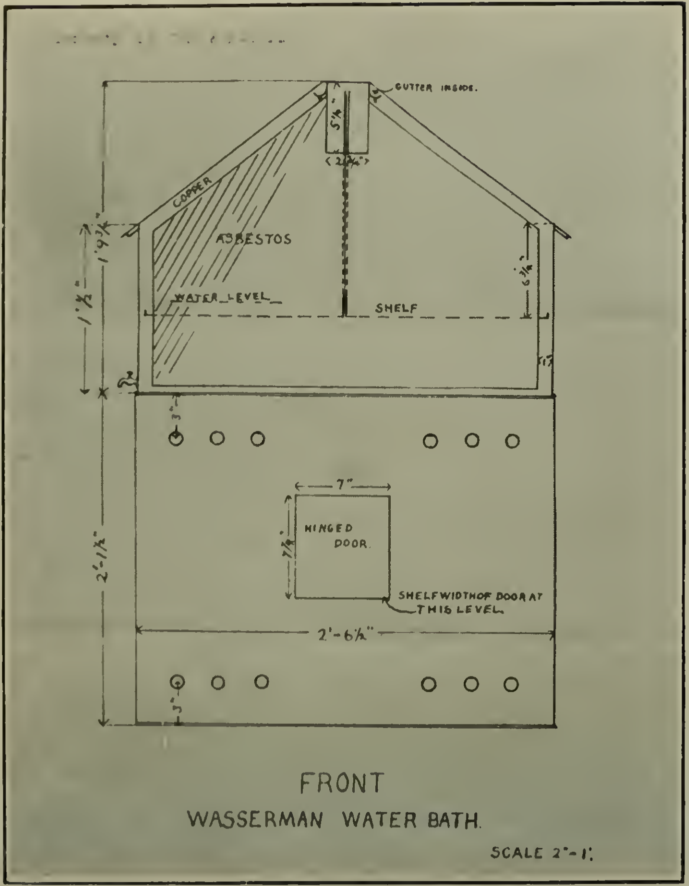

FIG. 14.—PLAN OF BATH SHOWN IN FIGURE 13.

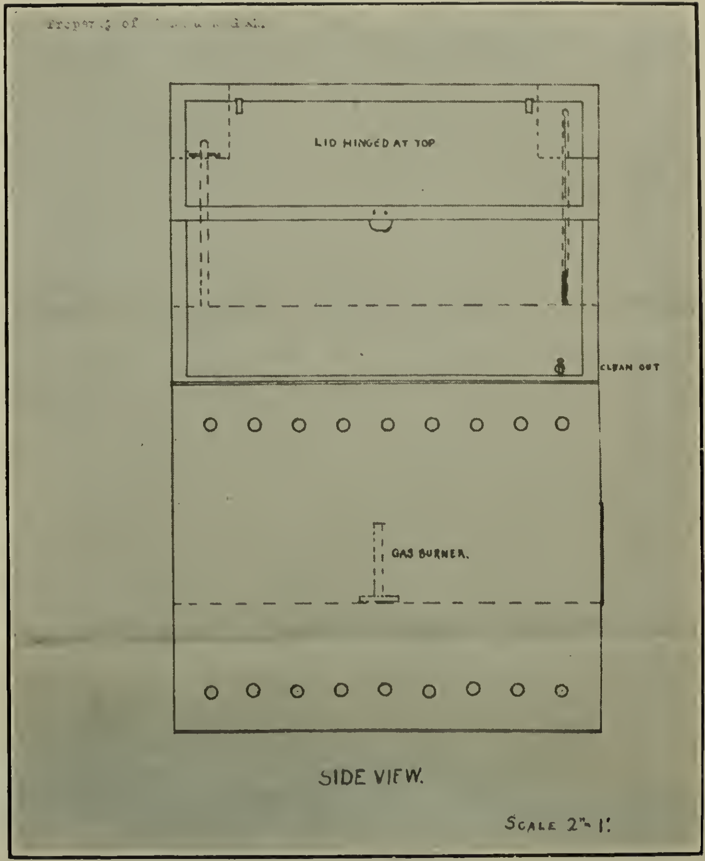

FIG. 15.—PLAN OF BATH SHOWN IN FIGURE 13.

size agreeing to two units of amboceptor, as shown by titration of the amboceptor. It should be noted also that the needles of the markers may be replaced should they become dull or broken, so that the apparatus is practically indestructible. Both the cutter and the markers were made by Topham, Washington, D. C., in accordance with specifications furnished from this laboratory. Cutters can be furnished at $4 each and markers at $2.50 each.

WATER BATH.

A satisfactory water bath for the incubation of the tests is sufficiently described in illustrations 13, 14, and 15. It is of such dimensions as to easily hold 25 of the standard racks already described. It is made by Lenz & Naumann, New York, and when fitted with thermoregulator, burner, and thermometer, costs $150.

READING THE REACTIONS.

After incubation and when the remaining red blood cells have settled sufficiently the tests are read. The racks are arranged in numerical sequence and each test is read by the operator by number. As the report is given on each test it is entered in the book by the assistant. As all tests are in the same numerical sequence in the book and in the racks, tube No. 1 is No. 1 in the book, tube 24 is test 24 in the book, etc. There is no possibility of error from the confusion of specimens, and the operator reads the tests with a mind unbiased by the knowledge of the name or condition of the patient.

The apparatus described above has been devised as the result of the experience of several years, during which a very large number of tests have been performed. It is believed that by the use of this method and this apparatus a large number of Wassermann reactions can be performed with great accuracy and speed. The method and apparatus are, therefore, particularly suited to the needs of laboratories in the military service and particularly for any new laboratories that may be established for the performance of the reaction on recruits.

Standard apparatus for the performance of the Wassermann reaction.

6	Macrae needles; can be purchased from Tieman, New York, each	$1.75
6	special needles for the collection of serum; made by Kny-Scheerer (figs. 3 and 4), each	.50
1	Record syringe, 1 c. c., No. 47792, A. H. Thomas Co., 1914	2.60
1	Luer syringe, 5 c. c., No. 47852, A. H. Thomas Co., 1914	3.50
1	Luer syringe, 10 c. c., No. 47852, A. H. Thomas Co., 1914	4.50
6	flasks, Ehrlenmeyer, 250 c. c	4.00
2	knives for cutting glass tubing	
75	pounds glass tubing; must be soft glass; 7 millimeters outside diameter, 6 millimeters inside diameter	30.00

6 triangular files, 3-inch, as per sample 4	
1,000 test tubes without lip, 100 by 13 millimeters	$20.00
3 round wire baskets for holding test tubes, 6 inches high by 7½ inches in diameter	1.50
1 centrifuge, electric, International Instrument Co., size 1, type A; 1 four 15 c. c. tube head and metal holders; 1 eight 15 c. c. tube head and metal holders; price approximately	62.00
Must specify whether for direct or alternating current, and also voltage desired. Price varies in accordance with current and voltage.	
16 centrifuge tubes, plain, 15 c. c	2.00
6 centrifuge tubes, graduated, 15 c. c	2.00
1 burner, compound blast, of Fletcher type, No. 23008, A. H. Thomas Co., 1914	10.00
1 blower, foot power, No. 21972, A. H. Thomas Co., 1914, 9 inches	8.00
These can only be used in posts with gas; if there is no gas, one burner, Bartel automatic for alcohol, No. 23024, A. H. Thomas Co., 1914, should be furnished; medium size	8.50
Pipettes:	
10 Mohr pipettes, 10 c. c. capacity, graduated in tenths each	.45
10 Mohr pipettes, 5 c. c. capacity, graduated in tenths each	.40
200 pipettes, serological, 1 c. c., graduated to tip in hundredths, No. 43496, A. H. Thomas Co., 1914, as per sample 5 each	.35
10 pipettes, 1 c. c., graduated to tip in hundredths, but with small bore so that more accurate measurement can be made each	.50
2 wooden trays for specimens (fig. 6)	
1 block for breaking specimen capsules (fig. 8)	
1 set of 20 copper test-tube racks; these are made by Topham, Washington, D. C.; price per set of 20	20.00
1 amboceptor cutter, made by Topham (figs. 10 and 11)	4.00
1 set of three amboceptor markers, consisting of one 4-mm. marker, one 5-mm. marker, one 6-mm. marker, made by Topham, at $4 each	12.00
1 copper paraffin bath to fit incubator, made by Topham	15.00
20 pounds soft paraffin, melting point 43° C.; can be obtained of A. H. Thomas Co. at 15 cents per pound	3.00
1 incubator; if electricity is available, Freas Electric Incubator, No. B. 5025, Eimer & Amend, New York; voltage must be specified	85.00
If gas is to be used, Boekels Bacteriological Incubator, Wm. Boekel & Co., Philadelphia; Cat. F, 1908, No. 1276; should be mounted on stand shown in 1285, same catalogue; price unknown.	
If gas incubator is furnished, the additional apparatus must also be furnished:	
1 thermoregulator, 48444, A. H. Thomas Co	12.50
1 Koch burner, 23140, A. H. Thomas Co., 6 inches	6.50
1 thermometer, 48368, A. H. Thomas Co., 10°–60°	5.00
1 water bath, complete, with thermometer, burner, and thermoregulator, as shown in figures 13, 14, and 15; Lenz and Naumann, New York	150.00
2 animal jars, No. 20224, A. H. Thomas Co., without top	1.00
1 bott. 30 gms. cholesterin	
1 bott. 500 gms. NaCl C. P	
1 bott. 500 cc. absolute alcohol	
6 animal cages, No. 20208, A. H. Thomas Co each	8.50
Total for permanent apparatus	551.60

Some arrangement must be made whereby guinea pigs, rabbits, and food for animals can be purchased as required.

The titration of all sera giving a double plus Wassermann.—As stated in the introduction, there is a great difference in the strength of double plus reactions. One-tenth of a cubic centimeter of some sera is required to give a double plus reaction, while one-thousandth of a cubic centimeter of another serum may be sufficient to give a double plus reaction.

The surgeon who receives the report in a given case therefore receives no accurate information as to the strength of the reaction in cases reported as double plus. The inadequacy of the information furnished is particularly apparent in certain cases having a double plus reaction after energetic treatment. After this treatment blood is again sent in, and still the laboratory returns a double plus reaction. Although the strength of the reaction may have been greatly reduced by this treatment, no indication of such a result is afforded by the simple double plus reaction.

For some time the writer has been investigating such cases by titrating the serum. In addition to the regular Wassermann six tubes are set up. In the first of these tubes is placed 1.9 c. c. salt solution, and 1 c. c. of salt solution is placed in the remaining five tubes. To the first tube 0.1 c. c. of the serum to be tested is added and thoroughly mixed. One cubic centimeter of this mixture is then carried over to the second tube and mixed with the salt solution in that tube. This operation is continued down to the last tube, when, after mixing, 1 cubic centimeter of the fluid is discarded. As a result of this operation the total volume left in every tube is 1 cubic centimeter, and the tubes contain accurate dilutions of the serum to be tested, as follows:

Tube	1	2	3	4	5	6
	0.05	0.025	0.012	0.006	0.003	0.0015

The Wassermann reaction is then performed in the usual manner in all of these dilutions.

As the result of such a procedure considerable information is secured. For example, a serum which when first sent in was double plus in the first three dilutions may after treatment be double plus only in the first dilution and negative in all others. If only the regular Wassermann had been performed in this case the reaction would have been double plus before and after treatment and the effect of the treatment would not have been demonstrated.

It is obviously undesirable to perform this titration in the case of sera that give less than a double-plus reaction, as this would cause an unnecessary amount of work and a useless expenditure of materials. It is equally clear that when sera are sent in there is no way of telling which cases will be double plus. In order to avoid this difficulty, the following procedure has been adopted in this laboratory. Each day when the reactions are performed the specimens are saved and replaced in the tray in their proper order. After the tests have been read, all specimens giving less than a double-plus reaction are discarded, and those specimens giving a double plus and containing sufficient serum are saved, and these sera are set up for titration on the next day the reactions are performed. The following blank form is then filled out and sent to the post surgeon:

ARMY MEDICAL SCHOOL,
Washington, D. C., July 10, 1915.

Results of titration of sera of cases which gave a double plus Wassermann on July 7, 1915.

Case.	Dilutions.						
	0.1	0.05	0.025	0.012	0.006	0.003	0.0015
John Smith	+ +	+ +	+ +	+	–	–	–

(Sgd.) ——— ———,
Major, Medical Corps.

It is believed that the adoption of this procedure will greatly increase the value of the Wassermann reaction both in diagnosis and treatment. It can only be followed when sufficient serum is sent. Post surgeons are therefore urged to send a sufficiency of serum collected in the manner described in this bulletin.

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WAR DEPARTMENT :: OFFICE OF THE SURGEON GENERAL

BULLETIN No. 9

OCTOBER, 1915

GUNSHOT ROENTGENOGRAMS

A COLLECTION OF ROENTGENOGRAMS TAKEN IN CONSTANTINOPLE DURING THE TURKO-BALKAN WAR, 1912-1913, ILLUSTRATING SOME GUNSHOT WOUNDS IN THE TURKISH ARMY

BY

CLYDE S. FORD
Major, Medical Corps

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No. 3.—Studies of Syphilis. By Charles F. Craig, captain, Medical Corps, United States Army, with introduction by Maj. Frederick F. Russell.

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WAR DEPARTMENT :: OFFICE OF THE SURGEON GENERAL

BULLETIN No. 9

OCTOBER, 1915

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GUNSHOT ROENTGENOGRAMS

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SOME GUNSHOT WOUNDS IN THE TURKISH ARMY

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CLYDE S. FORD
Major, Medical Corps

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UNITED STATES ARMY
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TABLE OF ILLUSTRATIONS.

RIFLE WOUNDS.

HEAD.

Page.
PLATE 1. Gunshot fracture, skull, lodgment of missile 12
2. Gunshot fracture, head, lodgment of missile 14
3. Gunshot fracture, lower jaw, ramus 16
4. Gunshot fracture, lower jaw, ramus 18
5. Gunshot fracture, lower jaw, body 20

SPINAL REGION.

6. Gunshot wound, spinal region, lodgment of missile 22
7. Gunshot wound, spinal region, lodgment of missile 24

UPPER EXTREMITY.

8. Gunshot fracture, humerus 26
9. Gunshot fracture, humerus, lodgment of missile 28
10. Gunshot fracture, humerus, lodgment of missile 30
11. Gunshot fracture, humerus 32
12. Gunshot fracture, humerus 34
13. Gunshot fracture, humerus 36
14. Gunshot fracture, humerus, lodgment of missile 38
15. Gunshot fracture, humerus, external condyle 40
16. Gunshot fracture (*a*) humerus, (*b*) ulna 42
17. Gunshot fracture, elbow 44
18. Gunshot fracture, elbow 46
19. Gunshot fracture, elbow 48
20. Gunshot fracture, elbow 50
21. Gunshot fracture, radius and ulna 52
22. Gunshot fracture, radius and ulna 54
23. Gunshot fracture, radius and ulna 56
24. Gunshot fracture, radius and ulna 58
25. Gunshot fracture, radius 60
26. Gunshot fracture, radius 62
27. Gunshot fracture, radius 64
28. Gunshot fracture, radius 66
29. Gunshot fracture, radius, lower end 68
30. Gunshot fracture, radius, lower end 70
31. Gunshot fracture, radius, lower end 72
32. Gunshot fracture, ulna 74
33. Gunshot fracture, ulna 76
34. Gunshot fracture, ulna 78
35. Gunshot fracture, ulna 80
36. Gunshot fracture, ulna 82
37. Gunshot fracture, ulna 84
38. Gunshot fracture, ulna 86

Page.
PLATE 39. Gunshot fracture, ulna 88
40. Gunshot fracture, ulna 90
41. Gunshot fracture, wrist 92
42. Gunshot fracture, wrist 94
43. Gunshot fracture, metacarpus 96
44. Gunshot fracture, phalanx 98

CHEST.

45. Gunshot wound, chest 100

PELVIS.

46. Gunshot wound, pelvis 102

LOWER EXTREMITY.

47. Gunshot wound, gluteal region 104
48. Gunshot wound, thigh 106
49. Gunshot wound, thigh 108
50. Gunshot wound, thigh 110
51. Gunshot wound, thigh 112
52. Gunshot fracture, femur 114
53. Gunshot fracture, femur 116
54. Gunshot fracture, femur 118
55. Gunshot fracture, femur 120
56. Gunshot fracture, femur 122
57. Gunshot fracture, femur 124
58. Gunshot fracture, femur 126
59. Gunshot wound, knee 128
60. Gunshot fracture, tibia and fibula 130
61. Gunshot fracture, tibia and fibula 132
62. Gunshot fracture, tibia 134
63. Gunshot fracture, tibia 136
64. Gunshot fracture, tibia 138
65. Gunshot fracture, tibia 140
66. Gunshot fracture, tibia 142
67. Gunshot fracture, tibia 144
68. Gunshot fracture, tibia 146
69. Gunshot fracture, tibia 148
70. Gunshot fracture, tibia 150
71. Gunshot fracture, fibula 152
72. Gunshot fracture, ankle 154
73. Gunshot wound, heel 156
74. Gunshot wound, heel 158

SHRAPNEL WOUNDS.

HEAD.

75. Gunshot fracture, vertex 160
76. Gunshot fracture, vertex 162
77. Gunshot fracture, zygoma 164
78. Gunshot fracture, mastoid process 166
79. Gunshot fracture, maxilla 168
80. Gunshot fracture, supra-orbital 170
81. Gunshot fracture, supra-orbital 172

UPPER EXTREMITY.

Page.
PLATE 82. Gunshot wound, shoulder 174
83 Gunshot wound, shoulder 176
84. Gunshot wound, shoulder 178
85. Gunshot wound, shoulder 180
86. Gunshot fracture, clavicle 182
87. Gunshot fracture, humerus 184
88. Gunshot fracture, humerus 186
89. Gunshot fracture, humerus 188
90. Gunshot fracture, humerus 190
91. Gunshot fracture, humerus 192
92. Gunshot fracture, humerus 194
93. Gunshot fracture, humerus 196
94. Gunshot fracture, humerus 198
95. Gunshot fracture, humerus 200
96. Gunshot fracture, humerus and elbow 202
97. Gunshot fracture, elbow 204
98. Gunshot fracture, elbow 206
99. Gunshot fracture, elbow 208
100. Gunshot fracture, elbow 210
101. Gunshot fracture, radius and ulna 212
102. Gunshot fracture, radius 214
103. Gunshot fracture, radius 216
104. Gunshot fracture, ulna 218
105. Gunshot fracture, metacarpus 220
106. Gunshot fracture, metacarpus 222
107. Gunshot fracture, metacarpus 224
108. Gunshot wound, hand 226
109. Gunshot wound, multiple, hand and forearm 228

CHEST.

110. Gunshot wound, chest 230
111. Gunshot wound, chest 232
112. Gunshot wound, chest 234
113. Gunshot wound, chest 236
114. Gunshot wound, chest 238

PELVIS.

115. Gunshot fracture, ilium 240

LOWER EXTREMITY.

116. Gunshot wound, thigh 242
117. Gunshot wound, thigh 244
118. Gunshot wound, thigh 246
119. Gunshot wound, femur 248
120. Gunshot wound, femur 250
121. Gunshot wound, femur 252
122. Gunshot wound, femur 254
123. Gunshot wound, femur 256
124. Gunshot wound, femur 258
125. Gunshot wound, femur 260
126. Gunshot wound, femur 262
127. Gunshot wound, femur 264

Page.
Plate 128. Gunshot wound, knee 266
129. Gunshot wound, knee 268
130. Gunshot wound, knee 270
131. Gunshot wound, knee 272
132. Gunshot wound, knee 274
133. Gunshot wound, knee 276
134. Gunshot wound, knee 278
135. Gunshot wound, leg 280
136. Gunshot wound, leg 282
137. Gunshot fracture, tibia and fibula 284
138. Gunshot fracture, tibia and fibula 286
139. Gunshot fracture, tibia and fibula 288
140. Gunshot fracture, tibia and fibula 290
141. Gunshot fracture, tibia 292
142. Gunshot fracture, fibula 294
143. Gunshot fracture, fibula 296
144. Gunshot fracture, fibula 298
145. Gunshot fracture, fibula 300
146. Gunshot fracture, fibula 302
147. Gunshot fracture, fibula 304
148. Gunshot fracture. "Pott's" 306
149. Gunshot wound, multiple, leg 308
150. Gunshot fracture, astragalus 310
151. Gunshot fracture, calcaneus 312
152. Gunshot wound, heel 314
153. Gunshot wound, heel 316
154. Gunshot wound, foot 318
155. Gunshot wound, foot 320
156. Gunshot wound, foot, multiple 322

OPERATIVE INTERFERENCE, GUNSHOT WOUNDS.

157. Gunshot fracture, humerus 324
158. Gunshot fracture, ulna 326
159. Gunshot fracture, radius and ulna 328
160. Gunshot fracture, tibia and fibula 330
161. Amputation, knee 332
162. Excision, head of humerus 334

INTRODUCTION

These roentgenograms are not presented as exhibiting a state of perfection in the art or method by which they were produced, although they show the results of some of the best and most modern apparatus of Europe employed in the hands of very skillful operators. Some plates are included which are indistinct and generally so unsatisfactory from a technical viewpoint as to be of little interest, if all of them were not intended to show the general character of the diagnostic assistance that the roentgenologist rendered the military surgeon in the base hospitals of Constantinople during the Turko-Balkan War.

The collection of these plates resulted from a systematic visiting of the hospitals of Constantinople in the winter of 1912–13, during the course of the first Balkan War, and including all of the military hospitals of the military zone, with the incidental purpose of selecting from the roentgenographic plates, which had been prepared wherever apparatus was installed, such examples of the roentgenography of gunshot wounds as might show characteristic lesions without relation to detailed clinical record.

More than 1,500 plates were examined, and from them more than 200 were selected as exhibiting some lesion that seemed to be characteristic of some form of gunshot wound, even though the case history could not be obtained. From these selected plates photographic prints were made. As some of these photographs displayed somewhat similar conditions, only 162 of them are herewith produced.

As the photographic and reproduction processes have transferred the rights and lefts of the original negatives several times, the plates as they appear here are interpreted, for right and left, as though they were the original photographic plates, which are physically positive although they are chemically negative; i. e., the right and left sides of the page should be read as the right and left sides anatomically. If this distinction be not observed, some confusion may arise from the habit of roentgenologists in regarding a roentgenograph as a positive print of a negative plate.

I regret that I can not here acknowledge by name my appreciation and gratitude to the roentgenologists of all hospitals from which I secured permission to reproduce their plates. To Prof. Wieting Pasha, the commandant of Gulhané Hospital; to Dr. Ishmael Bey, the roentgenologist of the Hamedian Hospital; to Dr. Englander, the roentgenologist of the Austrian Hospital—to all of whom I am particularly indebted—I wish to acknowledge my thanks.

Projectiles.—The projectiles which figure in the illustrations were those employed by the nations at war. They are derived (1) from the Turkish pointed bullet weighing approximately 15.0 grams—it is fired from the German Mauser and has all the ballistic values of the projectile from this weapon; (2) the Bulgarian bullet, blunt nosed or ogival headed and the same as the steel-jacketed bullet of the Austrian Mannlicher; (3) shrapnel balls and fragments of the shrapnel, and (4) fragments of steel shells from field artillery.

During the evolution of reduced caliber rifles experiments were made on cadavers at different ranges. In the published writings of these workers a great deal was said on the subject of highly destructive effects which are pretty generally described as *explosive effects.* The experimenters were careful to explain that these exaggerated and highly destructive effects were only seen when firing into cadavers at close ranges and when the bullet traveling at a maximum velocity happened to collide with resistant structures like the compact substance of bone in the diaphysis of the long bones, such as the femur, tibia, humerus, etc., and the head, as well as organs loaded with fluid or semifluid masses like the stomach, urinary bladder, and intestines. In other tissues offering but little resistance like lung tissues, soft parts generally, and epiphyseal ends of bone, the wounds inflicted were considered humane in character. Attention should be called to the infrequency of wounds showing explosive effects by the rifles of reduced caliber employed in the Turko-Balkan and Spanish-American wars. The same thing may be said of the Turko-Italian, Anglo-Boer, and Russo-Japanese wars, all of which were fought with the new armament.

The reason for the infrequency of the explosive effects in these wars is due to the fact that the battles were fought in the open at the ordinary battle ranges beyond the zone of explosive effects. This fact is all the more emphasized in the present world war, in which the rifle fire is employed principally in trench warfare at near-by ranges, and where all the wounds which involve the resistant structures of the body show the characteristic features usually described as those of explosive effects.

In describing the plates the terms used in connection with range are as follows:

(1) Close range, from 0 to 100 yards.
(2) Short range, from 100 to 500 yards.
(3) Mid range, from 500 to 1,000 yards.
(4) Long range, from 1,000 to 2,000 yards.

The wound effects of the modern military rifle bullet at various ranges are usually classified as follows:

(1) Explosive range, from 0 to 500 yards.
(2) Perforating range, from 500 to 1,500 yards.
(3) Penetrating range, from 1,500 to 2,500 yards.

The difficulty in adhering strictly to the last table as far as the characteristic features of wounds are concerned is this: In battle the chances of ricochetting of bullets is said to be in the proportion of one to three. Naturally, the moment a bullet ricochets it loses more or less of its remaining velocity. The destructive lesion to be expected from a given shot at a given range against a certain resistant structure can not be depended upon to occur as it will when the shot is made with scientific accuracy in the shooting gallery against cadavers.

Trajectory, or the curved line of flight of a projectile, has nothing to do with its wound-producing quality, except to increase the wound-producing frequency when it flattens and approaches the straight line of sight, because it will then pass through a greater portion of the space between the gun and the target, which may be occupied by men, without going over their heads. The greater the velocity, the flatter the trajectory becomes.

The American, German, and Turkish rifles, with about the same trajectory, can be fired through a tube 24 inches in diameter at a range of 500 yards, and the vertical rise of the curve of flight would not hit the top of the tube. But where the range is increased to 1,000 yards it would be necessary to enlarge the tube to a tunnel. 15 feet in diameter, in order to fire the bullet through it without striking the top in its greatly increased curve in flight.

Velocity is the principal factor of the wound-producing power of the small-caliber bullet, although the latter quality is definitely related to the cross-sectional area and weight as well as to the hard metal jacket which preserves its form. The greater the velocity of any particular bullet the more serious is its wound.

Energy, as the resultant of the components of *weight* and *velocity*, represents the *real* damaging quality, striking force, or "punch" of a projectile, with a variation in wound effect as the energy is distributed over the surface of the body, through the cross-sectional area and the form of the point of the projectile, and the elements of construction which affect the preservation of its shape. As the energy is expressed in the formula, $E=\frac{WV^2}{2g}$, it is evident that the increase or decrease of the velocity factor gives greater variation than the increase of weight.

Range is important only as indicating the amount of *remaining energy* which may be known to reside in the projectile at any stage of its flight. Without reference to the ballistic condition (velocity, weight, form, and construction, etc.) of a particular projectile, *range* has no surgical significance. To the military surgeon, however, it is a term of the greatest interest when these ballistic conditions are known, as it gives him a very definite indication of the remaining energy or the damaging effect of a projectile at the different stages in its flight.

The remaining energy of the American "Springfield," or German "S" bullet, for instance, will pass it through the bodies of two men at 2,000 yards and an energy of 8 kilogram-meters, which remains at about twice that distance, will cause a disabling wound.

Wound infections are more rare in campaign in the more sparsely settled and rough countries with soldiers of the more primitive class, simple domestic habits, and greater natural resistance.

Wound treatment should be primarily directed toward the control of infection with only secondary regard for the correction of deformities which should follow as a secondary measure after resolution is established.

All treatment should be based on principles applied in the following order:

(1) Life saving.
(2) Restoration of function.
(3) Economy of the patient.

Amputation should be very rare.

Conservation to a degree that seems to be beyond the experience and conception of the civil surgeon should always be practiced, as reiterated by Delorme, who says: "In order to avoid the excess of operative measures which has been seen in recent wars I am urged to enjoin all potential military surgeons to practice almost uniform conservation."

Weight and muzzle velocity of several projectiles.

Projectile.	Weight.		Velocity.	
	Grams.	Grains.	Meters.	Feet.
American (Springfield)	9.07	150	800	2,700
French	12.8	197	701	2,301
German	10.0	154	860	2,821
Austrian	15.8	244	626	1.952

Plate 1.

Rifle—Plate 1.

HEAD.

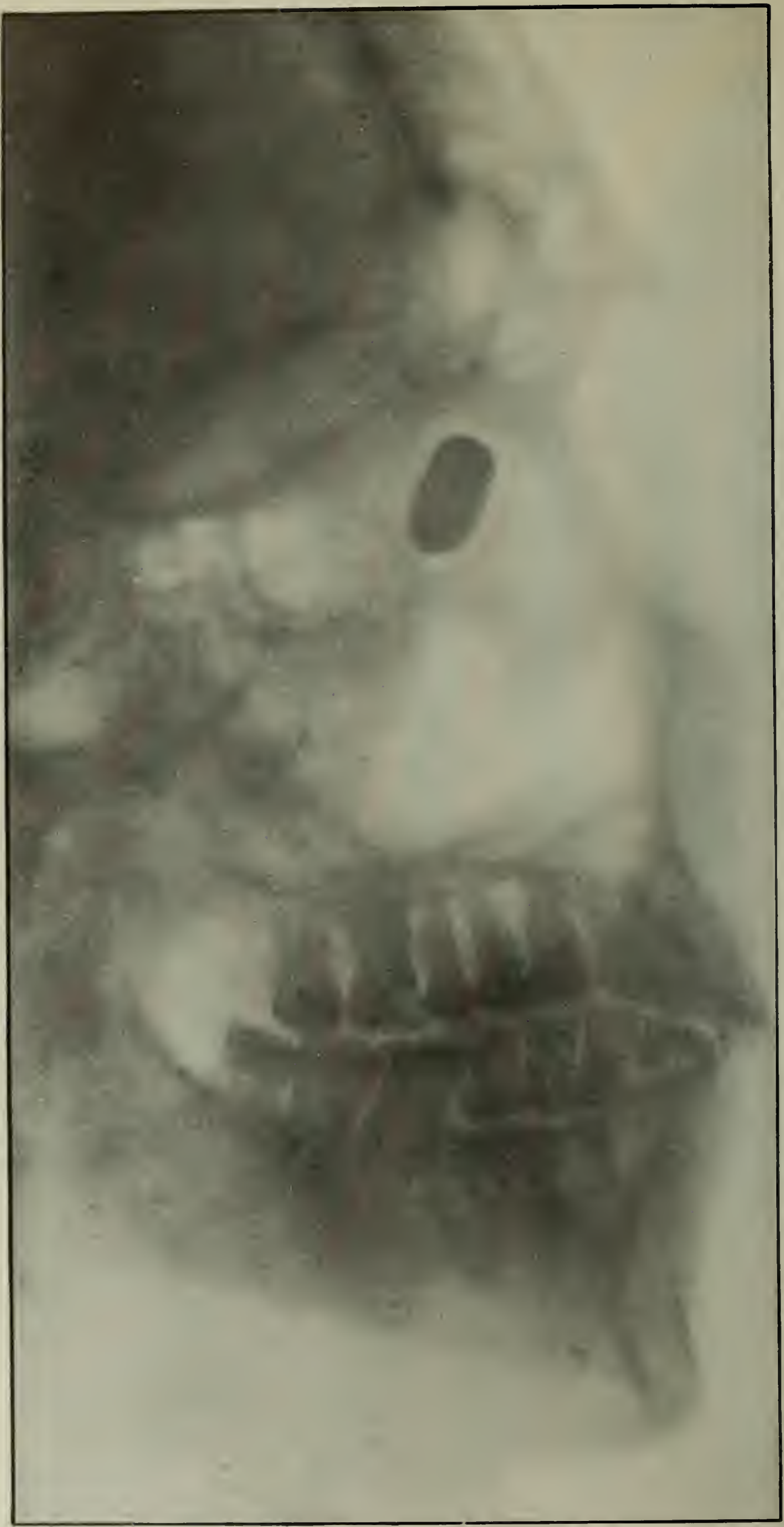
Gunshot Fracture of the Skull, with Lodgment of the Missile.

The bullet in this case was so badly deformed by ricochet that part of both core and jacket were lost. While the appearance of the shadow seems to indicate a direct impact of the nose of the bullet, the line of contact with the skull must have been tangential, with some laceration of the scalp; otherwise a cursory examination of the scalp wound would have revealed the slightly protruding end of the bullet. The dark shadow above the projectile is due to material used in dressing. The great thickening of the scalp in the region of the wound shows a marked cellulitis. Small particles of the lead core of the bullet can be seen about the wound.

In such cases there is often a marked infection of the scalp without extension of infection to the cranial cavity, except from neglect. This is a case, though apparently simple, in which the radiograph was necessary for correct diagnosis without exploration.

The treatment in such cases is conservative, with removal of the projectile and care of the superficial infection or subsequent complications.

Plate 2.



RIFLE—PLATE 2.

HEAD.

Gunshot Wound of the Head, with Lodgment of the Missile.

Wound of entrance, near outer canthus, with course through eyeball to ethmoid body.

Wound of exit, none.

The Bulgarian Mannlicher bullet, shown half actual size on the plate, must be inclined on its long axis, about 30° from the perpendicular, to the plane of the plate.

The slight penetration of the missile and its normal character show that, having struck no intervening object, it inflicted the wound at extreme range.

The treatment should meet the indication for removal of missiles in all superficial or easily accessible locations and when they cause reaction.

Results to be expected are favorable except for loss of the eye.

Plate 3.

RIFLE—PLATE 3.

HEAD.

Gunshot Fracture of the Ramus of the Lower Jaw.

Wound of entrance, in the cheek behind the angle of the mouth.

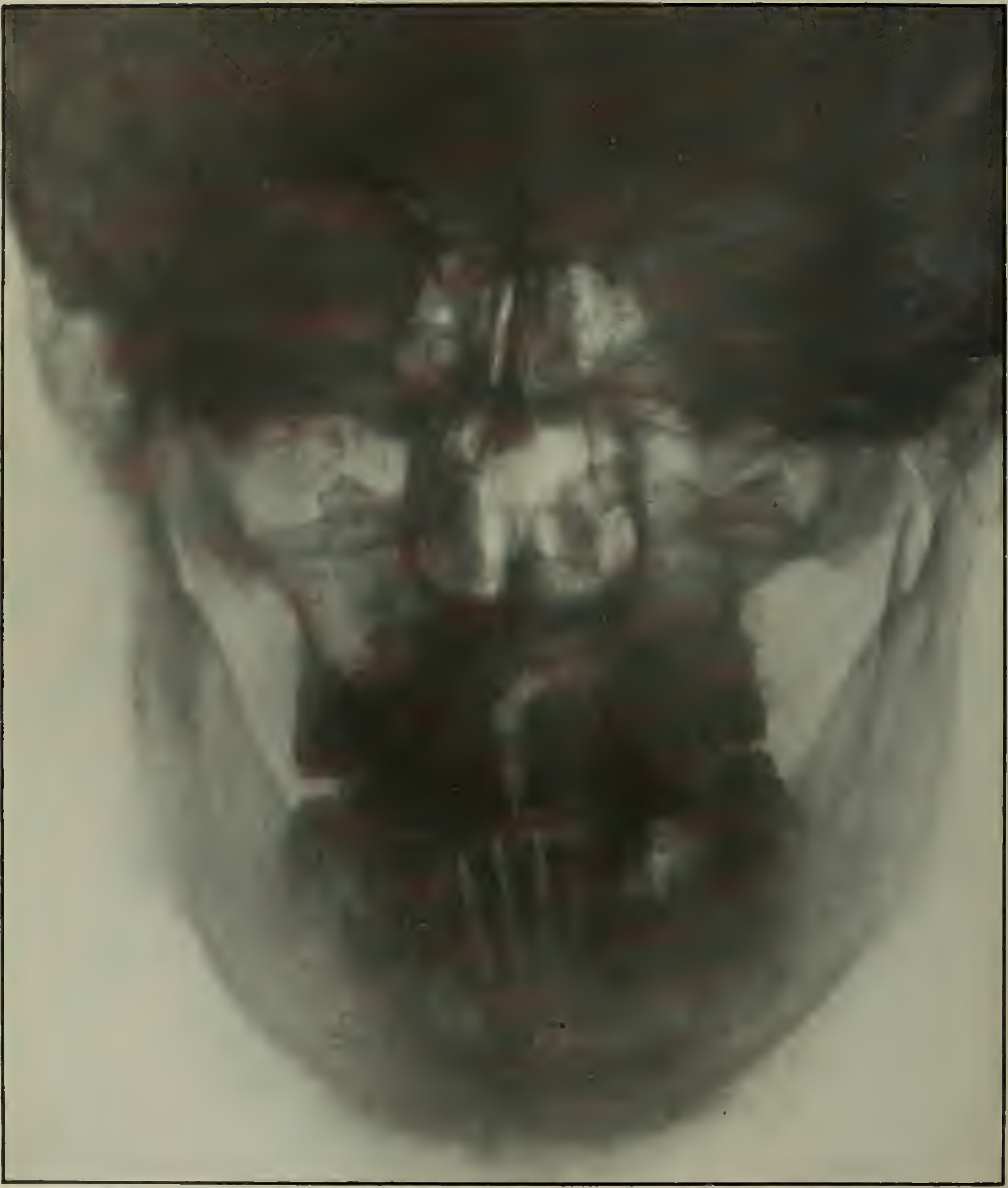
Wound of exit, below the tip of the mastoid.

The course of the bullet was almost tangential to the ramus of the jaw, anteroposteriorly. The slight fragmentation, which is hardly more than a splitting of the bone, with little or no displacement, indicates that the wound was made by a rifle bullet at moderate velocity and at mid or long range.

Treatment is expectant.

Results are favorable.

Plate 4.



RIFLE—PLATE 4.

HEAD.

Gunshot Fracture of the Ramus of the Lower Jaw.

Wound of entrance, over the anterior border of the right ramus.

Wound of exit, beneath the lobe of the ear.

The wound was made by a rifle bullet with the velocity of long range, because wounds of a shrapnel ball never show such slight injury without lodgment or without marks of lead.

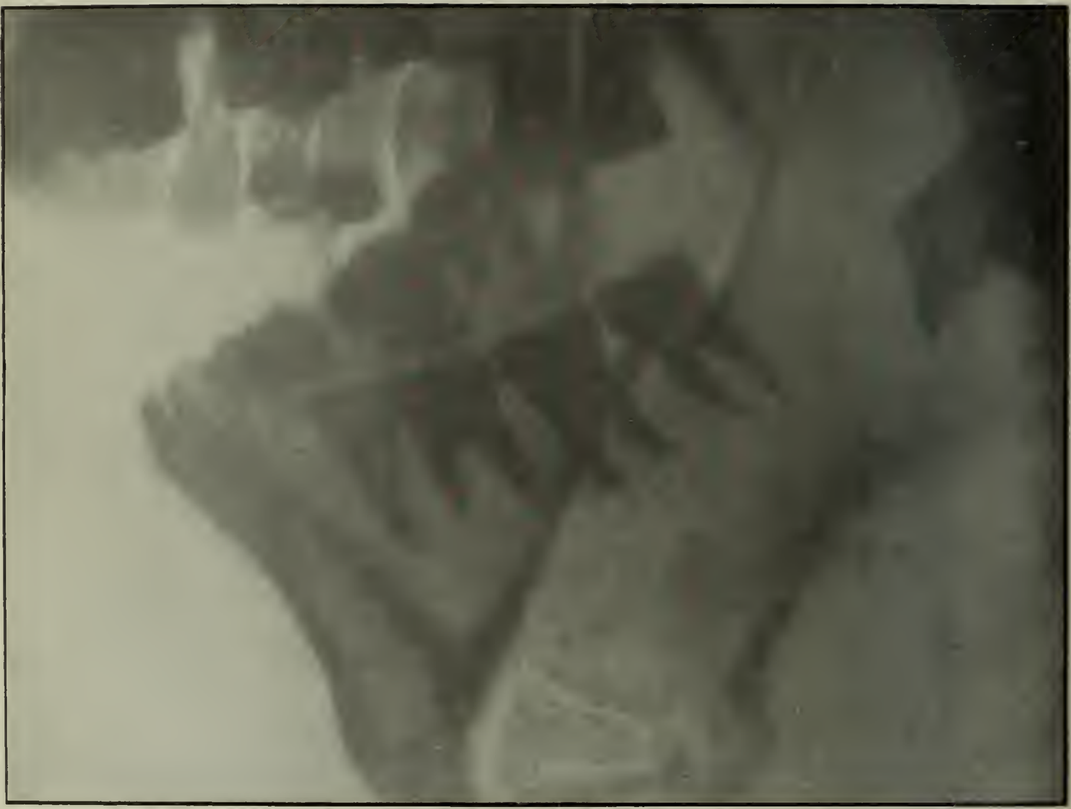
The damage of the bone was very slight, as only a superficial fragment was chipped off. There were no signs of primary infection. Reaction and periostitis suggested the radiograph after infection had rarefied the fragment, shown but very faintly on the left side of the plate.

The postero-anterior skull radiograph was made with the face superimposed upon the photographic plate.

Treatment, incision and drainage.

Results, good.

Plate 5.



RIFLE—PLATE 5.

HEAD.

Gunshot Fracture of the Body of Lower Jaw, with Great Fragmentation and Displacement.

Wound of entrance, to the left side of the median line of the lower jaw below the alveolar process, with course ranging downward and backward.

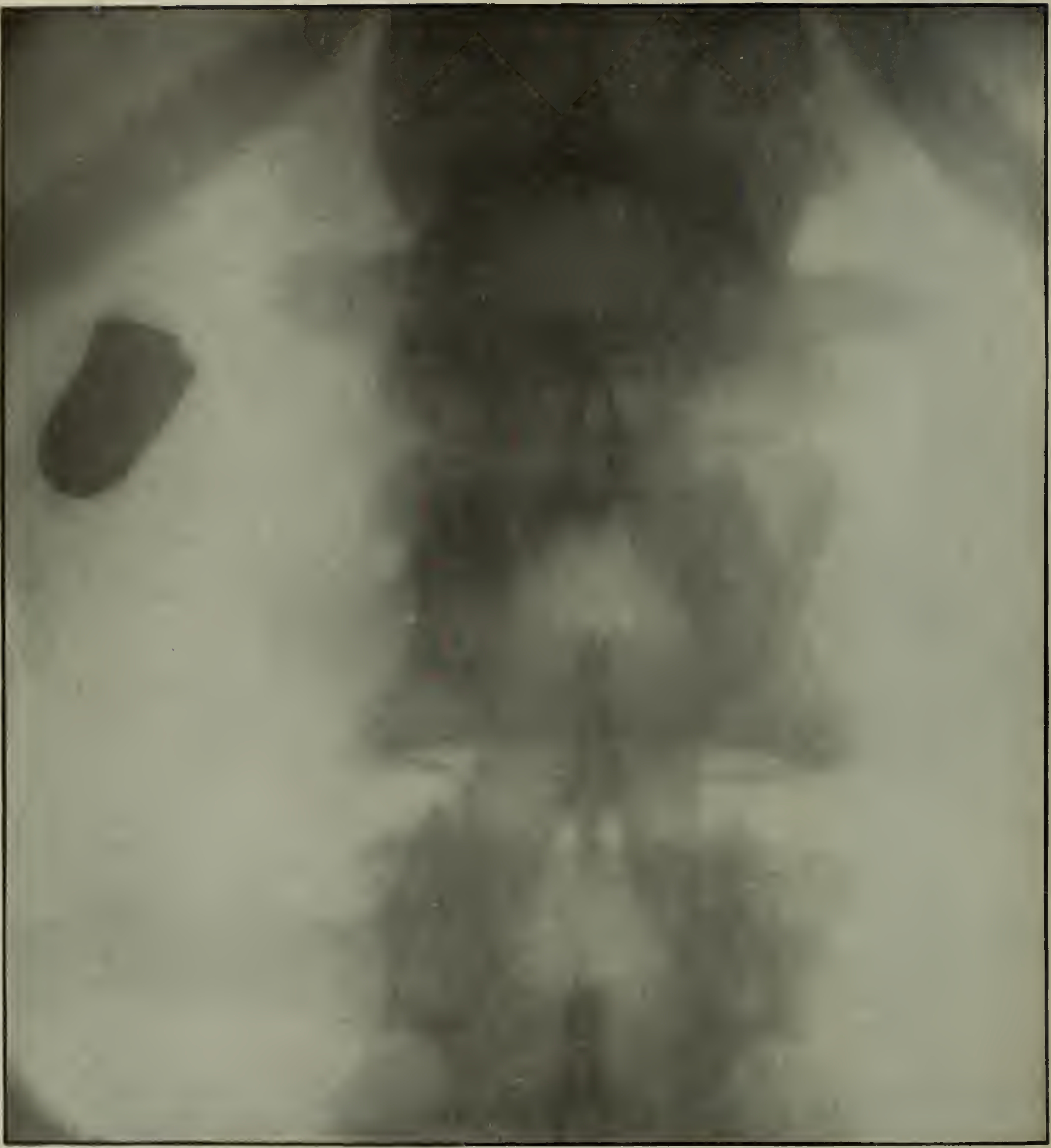
Wound of exit, with extensive laceration, beneath lower border of the bone.

The wound was caused by a rifle bullet at high velocity at or less than mid range. The fragments are many and rather small, so that much bone was lost through the wound of exit. This effect was produced by the splitting due to the relative friability of the bone and to the imparting of the momentum of the missile to the detached fragments, which, together with the missile, effected the considerable laceration of the wound of exit.

Treatment, difficult; guided by septic conditions and surgical means available.

Results in such cases are favorable to life but topically unsatisfactory.

Plate 6.



RIFLE—PLATE 6.

SPINAL REGION.

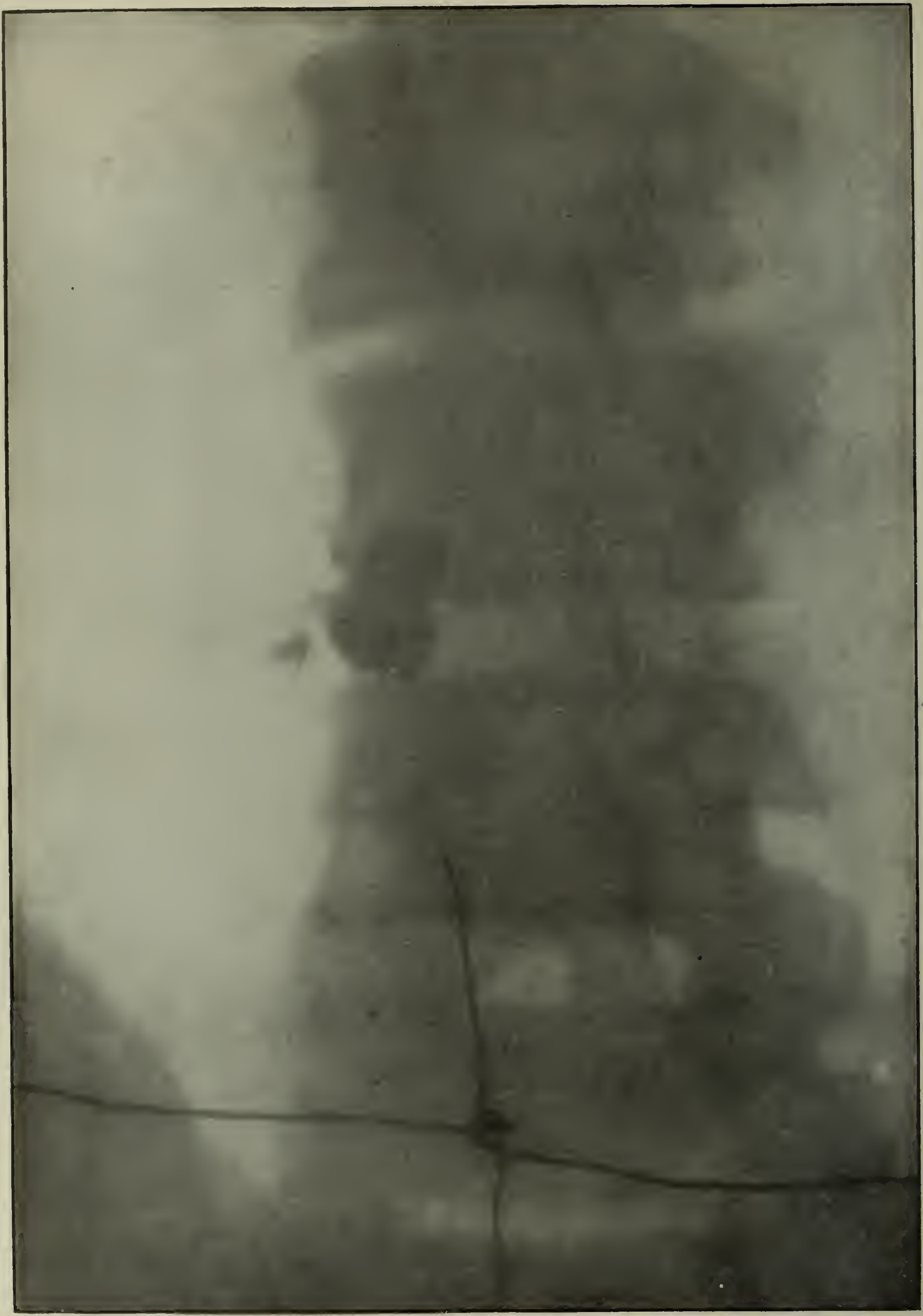
Gunshot Wound of the Spinal Region—Lodgment of the Missile in the Lumbar Muscles.

The bullet is lodged deep in the muscles of the back and not in the abdomen, as determined by inspection of the plate.

(*a*) The shadow of the bullet is enlarged laterally, because, while on the side of the body next to the plate and to the spine, it is at some little distance from the plate, which accounts for the larger diameter of the shadow; and it is shortened longitudinally, because its long axis is inclined at an angle to the plate.

(*b*) The outline of the shadow is distinct, an evidence that it is extra-abdominal, as otherwise its outline would be blurred by the diaphragmatic movement of respiration imparted to the abdominal viscera during the Röntgen exposure.

Plate 7.



RIFLE—PLATE 7.

SPINAL REGION.

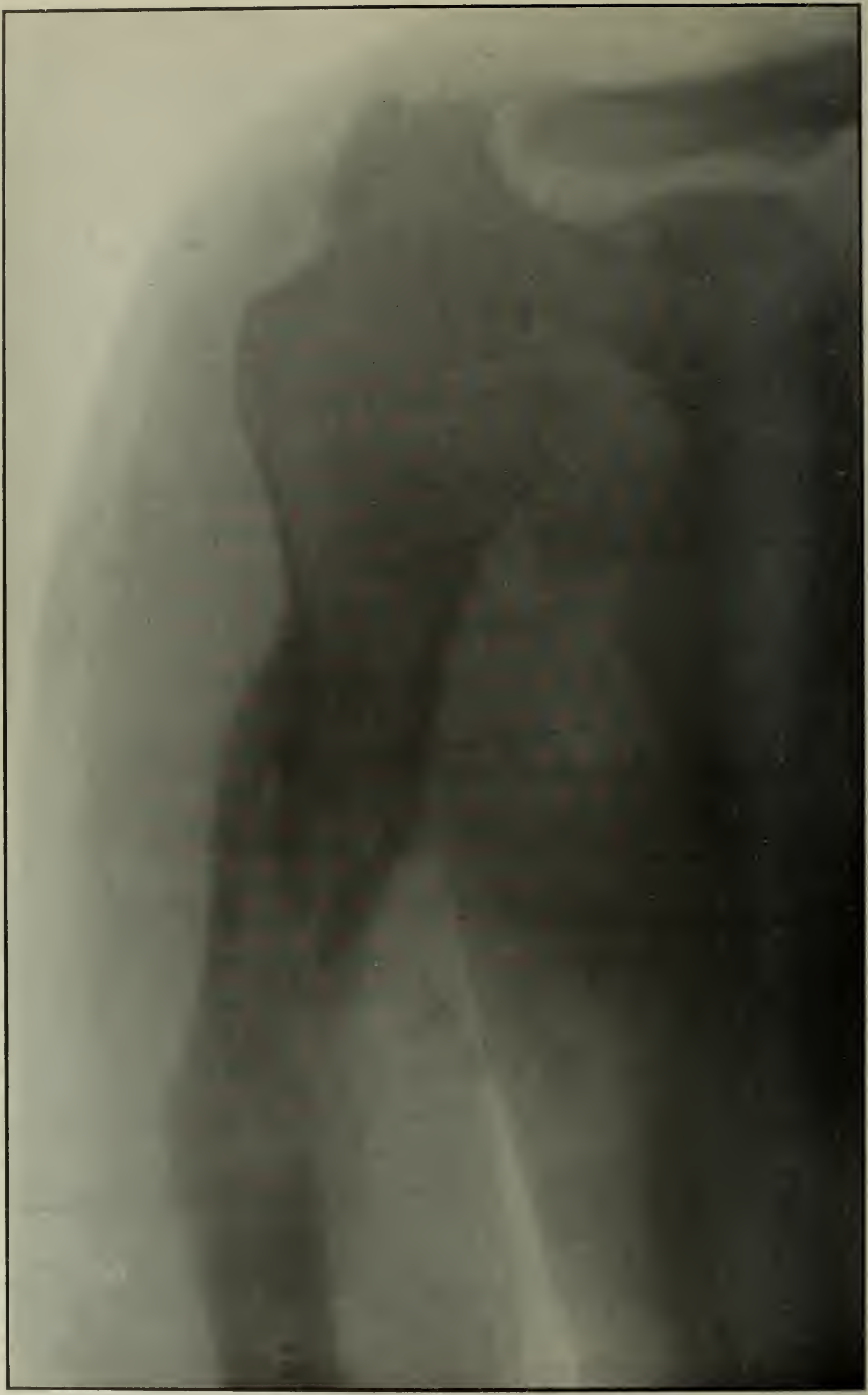
Gunshot Wound of the Spinal Region, with Lodgment of the Missile.

The bullet was either dumdummed or unjacketed, because its soft nose mushroomed, striking the crest of the ilium, penetrated the lumbar muscles, and struck the side body of the third lumbar vertebra without producing fracture.

The exposure, as the spinous processes show, was made with the spine next to the plate, and the slight shadow, somewhat larger than the projectile—to judge the size from the undeformed diameter—shows it to be anterior to the vertebra. The shadow is deep enough to indicate the location fairly near to the plate and, almost certainly, not in the abdominal cavity, where the distance from the plate would have made the shadow less dense and the movement of respiration probably would have given it a blurred outline. The shadow of the localizing cross gives a standard of density to be compared with the shadow of the projectile in making the estimation.

The treatment is conservative; only pain, paralysis, impaired function, or sepsis indicate interference.

Plate 8.



Rifle—Plate 8.

UPPER EXTREMITY.

Compound Fracture of the Humerus in Advanced State of Repair with Callus Formation.

Wound of entrance, just above middle of anterior aspect of arm.

Wound of exit, about the same height, posteriorly.

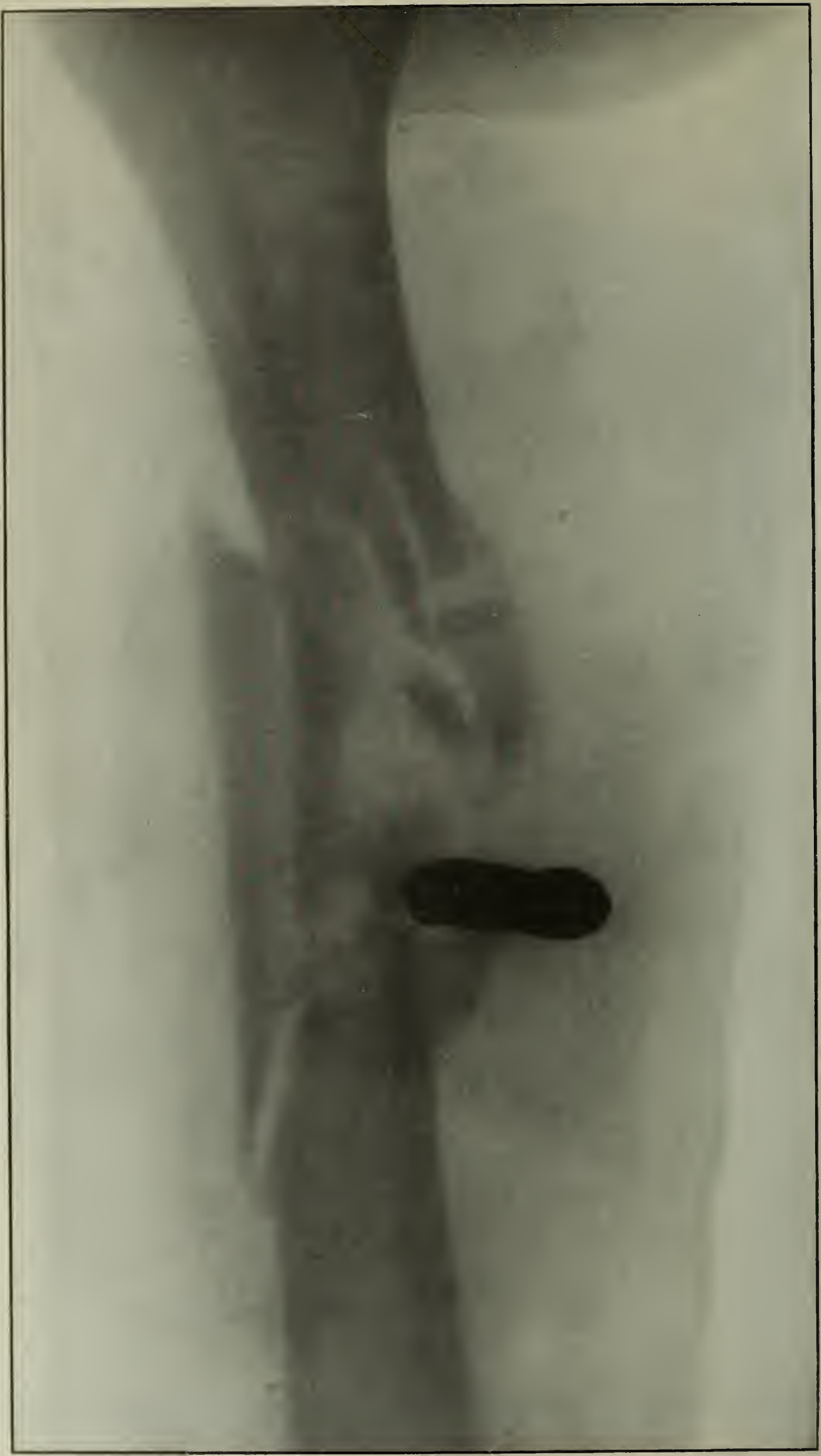
The course of the missile was anteroposterior, with high velocity of short range through the bone with a splitting effect, leaving a few fragments, large and small, which were not much displaced and caused but little deformity.

Wound was not infected. The absorption of smaller and the overlapping of larger fragments caused some shortening.

Treatment, expectant.

Results, favorable.

Plate 9.



Rifle—Plate 9.

UPPER EXTREMITY.

Gunshot Fracture of the Right Humerus, with Lodgment of the Missile.

Wound of entrance, antero-external aspect of upper third of arm.

Wound of exit, none.

The missile, deformed by ricochet, struck the bone with greatly reduced velocity and without sufficient energy to perforate the bone by which it was deflected slightly from its course and lodged in the arm.

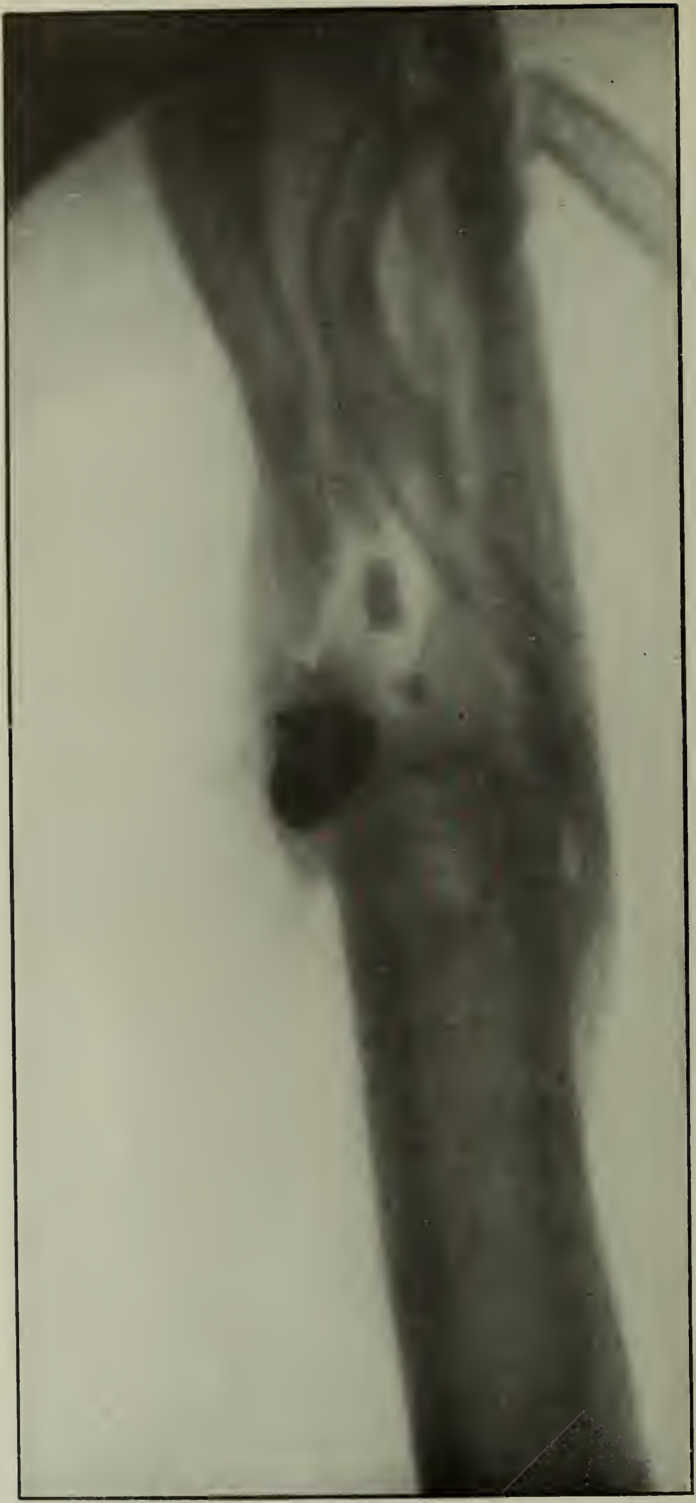
This is something of the same effect that might have been caused by a shrapnel ball, under the same ballistic conditions with a normal shrapnel velocity giving about the same penetrating force.

The wound, without infection, is in the first week or two of repair, before any callus has formed.

Treatment is expectant.

Results favorable.

Plate 10.



RIFLE—PLATE 10.

UPPER EXTREMITY.

Gunshot Fracture of the Left Humerus, with Lodgment of the Missile.

Wound of entrance, anterior surface of upper third of the arm.

Wound of exit, none.

The shadow of the missile shows by its distinct outline and normal diameter at the tip that the missile lies on the side near the plate; the shortened length of the projectile indicates that the long axis lay in an acute angle with a perpendicular to the plate.

The irregular outline of the base of the shadow and the fact of lodgment shows that the missile was deformed and that it was incidentally retarded in velocity by ricochet, so that its penetrating force was not sufficient to carry it through the arm.

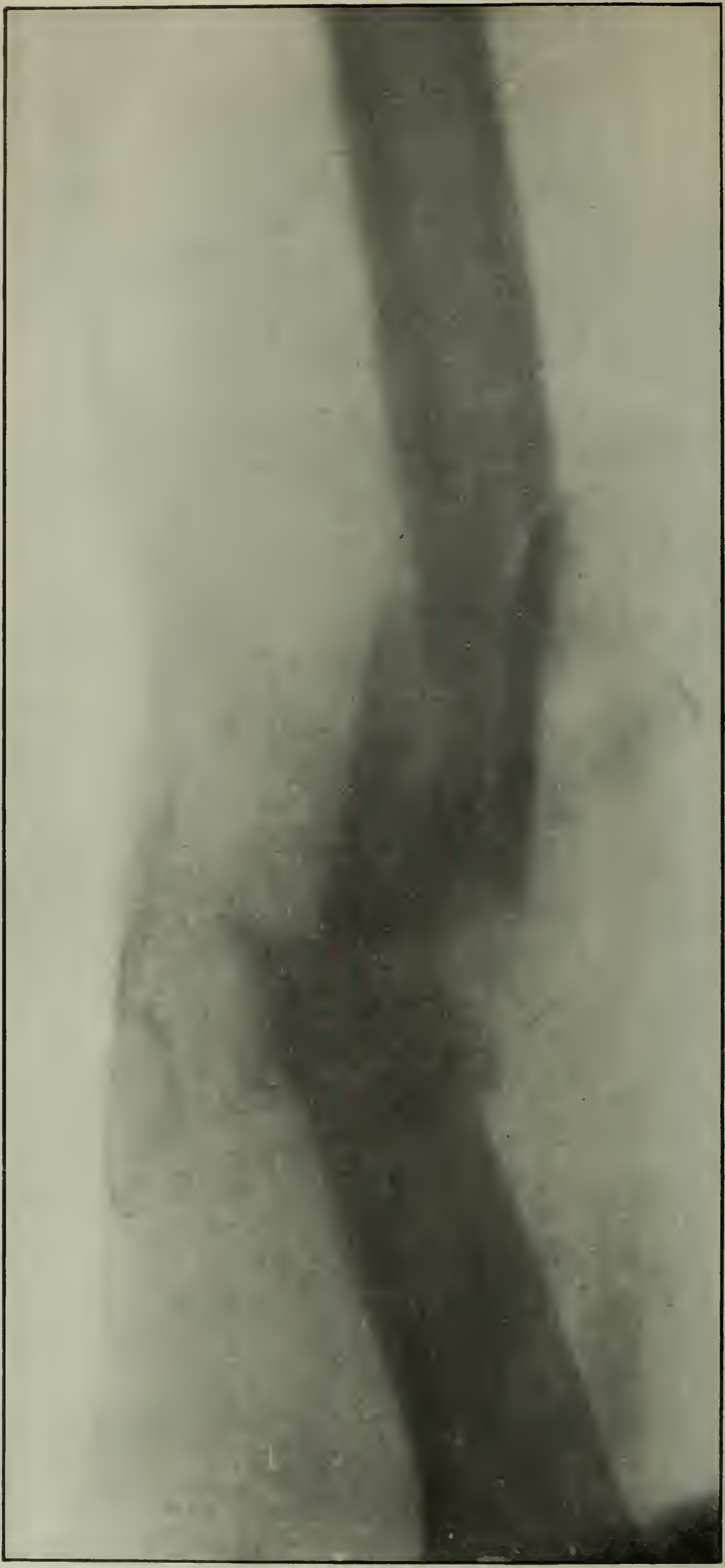
The fragments of bone are large and the wound is of the same character as might have resulted from a shrapnel ball, for the normal ballistic conditions of the latter simulate the conditions that produced the wound.

The drainage tubes seen in the plate indicate infection.

The conventional treatment in such cases is drainage and other management of the infection without formal search for the projectile.

Results should be favorable.

Plate 11.



RIFLE—PLATE 11.

UPPER EXTREMITY.

Gunshot Fracture of the Humerus.

Wound of entrance, anterior internal aspect of middle and upper third of arm.

Wound of exit, opposite.

The missile has struck the side of the bone and pursued a course through the shaft, so that a transverse fracture, as well as the separation of several medium-sized fragments, resulted from the splitting effect of the missile.

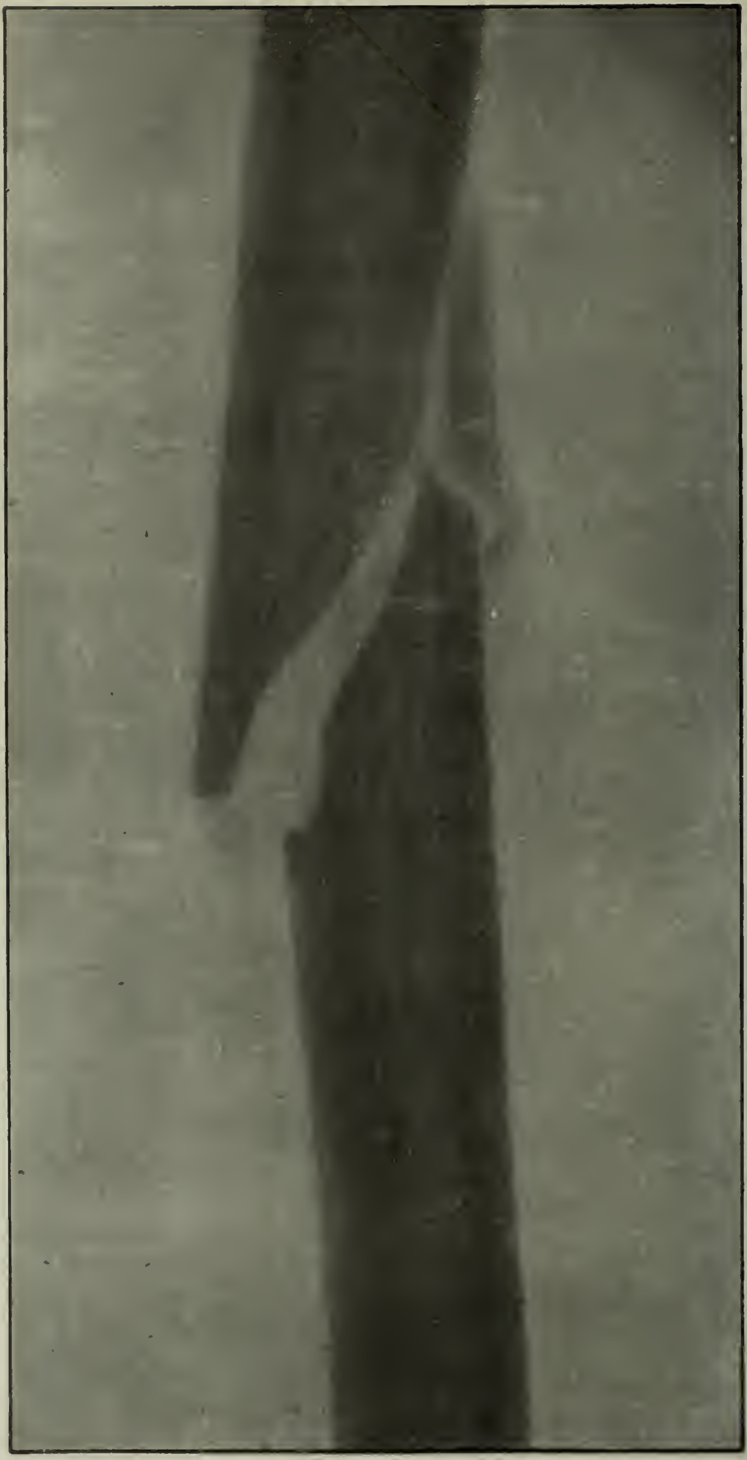
A larger missile, i. e., a shrapnel ball, with the same striking energy could have been stopped by the bone, but a wider distribution of the same energy carried by a larger cross section would have produced larger fragments.

In this case the location of the shrapnel ball would furnish unquestioned evidence; or, if a shrapnel ball had produced this particular bone destruction, its path among the fragments would have been marked by traces of lead. Two metal fragments indicate that the lead core of the bullet was exposed.

The wound, not infected, was treated expectantly.

Result in such cases is favorable.

Plate 12.



RIFLE—PLATE 12.

UPPER EXTREMITY.

Gunshot Fracture of the Humerus.

The course of the missile was anteroposterior through the middle of the arm.

The ballistic conditions and lines of force applied to the bone were somewhat, if not entirely, similar to those producing the fracture shown in plate 11. The missile struck the wall of the shaft without passing through the medullary canal, but a secondary fragmentation of the two large fragments did not follow except for the breaking of the tip of the distal fragment.

The range was long.

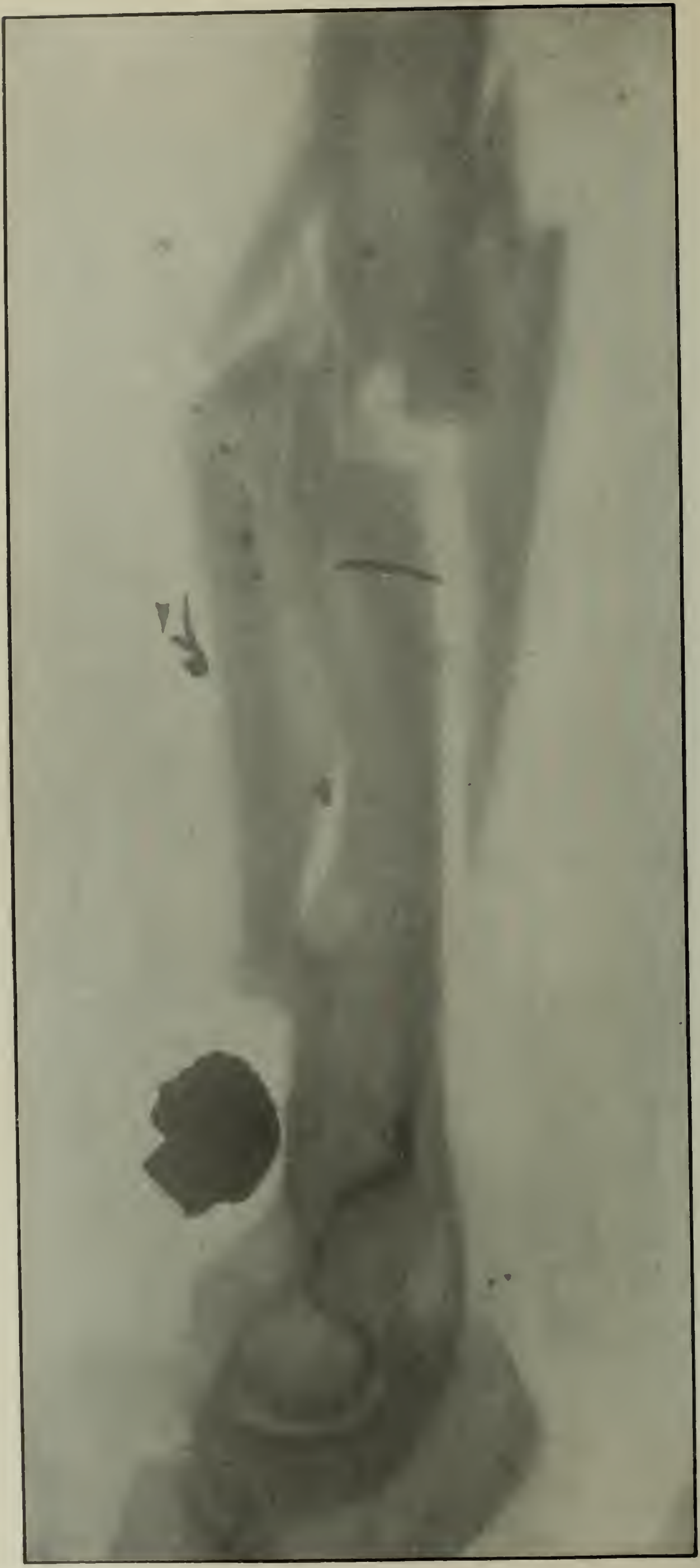
There was little deformity and no infection.

Plaster dressing was applied and the slight outline of callus formation indicates the process of repair. The lack of contrast in the shadow of the bone is due to the opacity of the plaster dressing through which the Roentgen exposure was made.

Treatment in such cases is expectant.

Results should be uniformly good.

Plate 13.



RIFLE—PLATE 13.

UPPER EXTREMITY.

Gunshot Fracture of the Right Humerus, with Lodgment of the Missile.

Wound of entrance, about middle of the anteriorinternal aspect of the arm.

Wound of exit, none.

The course of the missile was from without, downward and inward to a point of lodgment above the internal condyle. The distinct outline and normal size of the base of the bullet shows it to be near the plate, with the internal condyle next to the plate in the exposure.

The bullet mushroomed when it struck the bone with a "soft nose," in which the lead was not protected by a tough metal jacket. It may have been dum-dummed; it is remotely possible that the nose of the jacket was split by ricochet, or it is more probable that it was of the unjacketed variety.

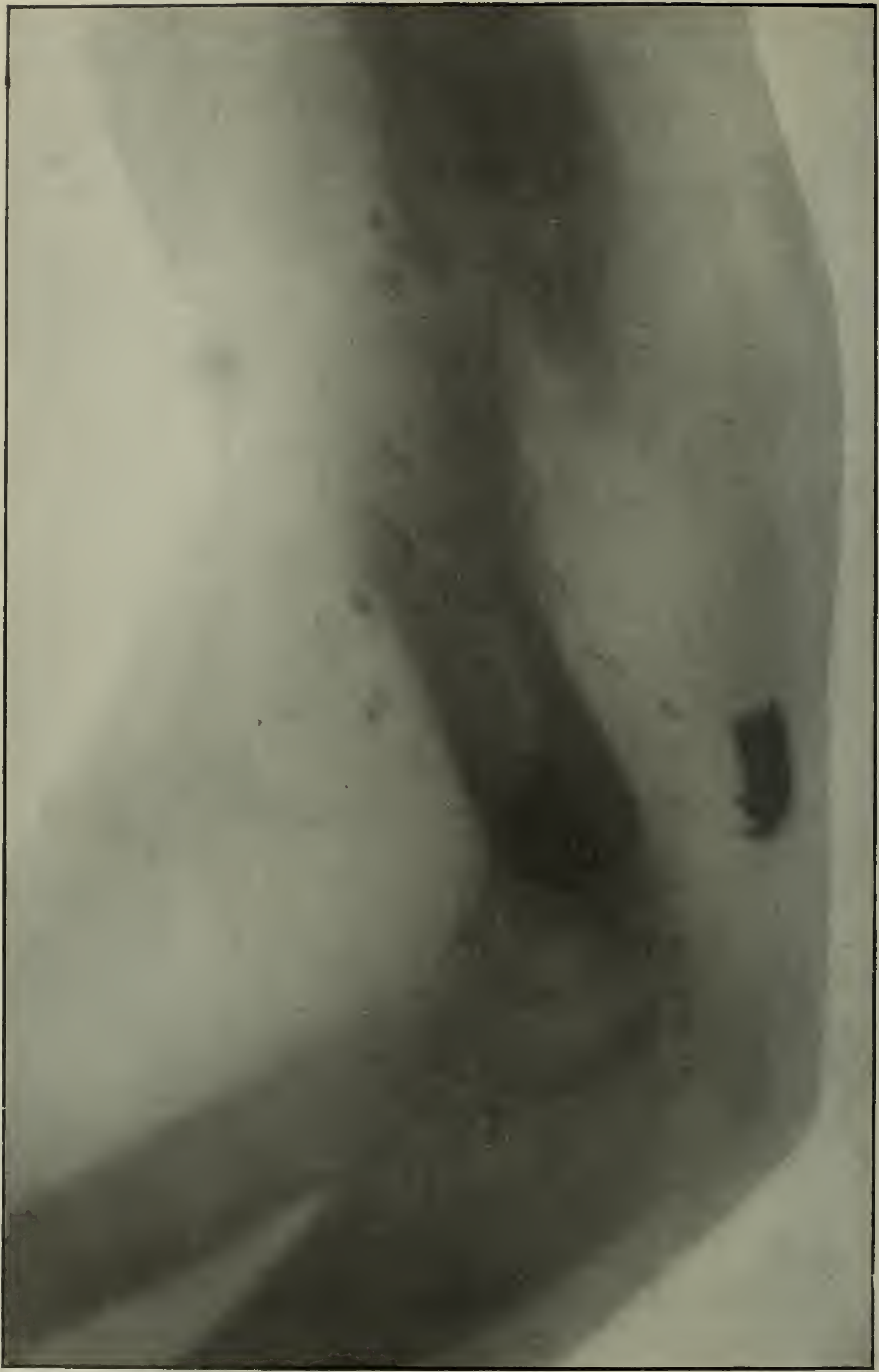
The effect is identical with that of a shrapnel ball, striking with its normal low velocity, which is about the same as that of the missile in this wound.

The invariable characteristic of a shrapnel wound of a bone, namely, the small particles of metal marking its course in contact with the bone, is seen in this plate.

The treatment in such cases is expectant, with due regard to the character of the infection, and without primary search for the missile.

The results are generally favorable.

Plate 14.



Rifle—Plate 14.

UPPER EXTREMITY.

Gunshot Fracture of the Humerus, with Lodgment of the Missile.

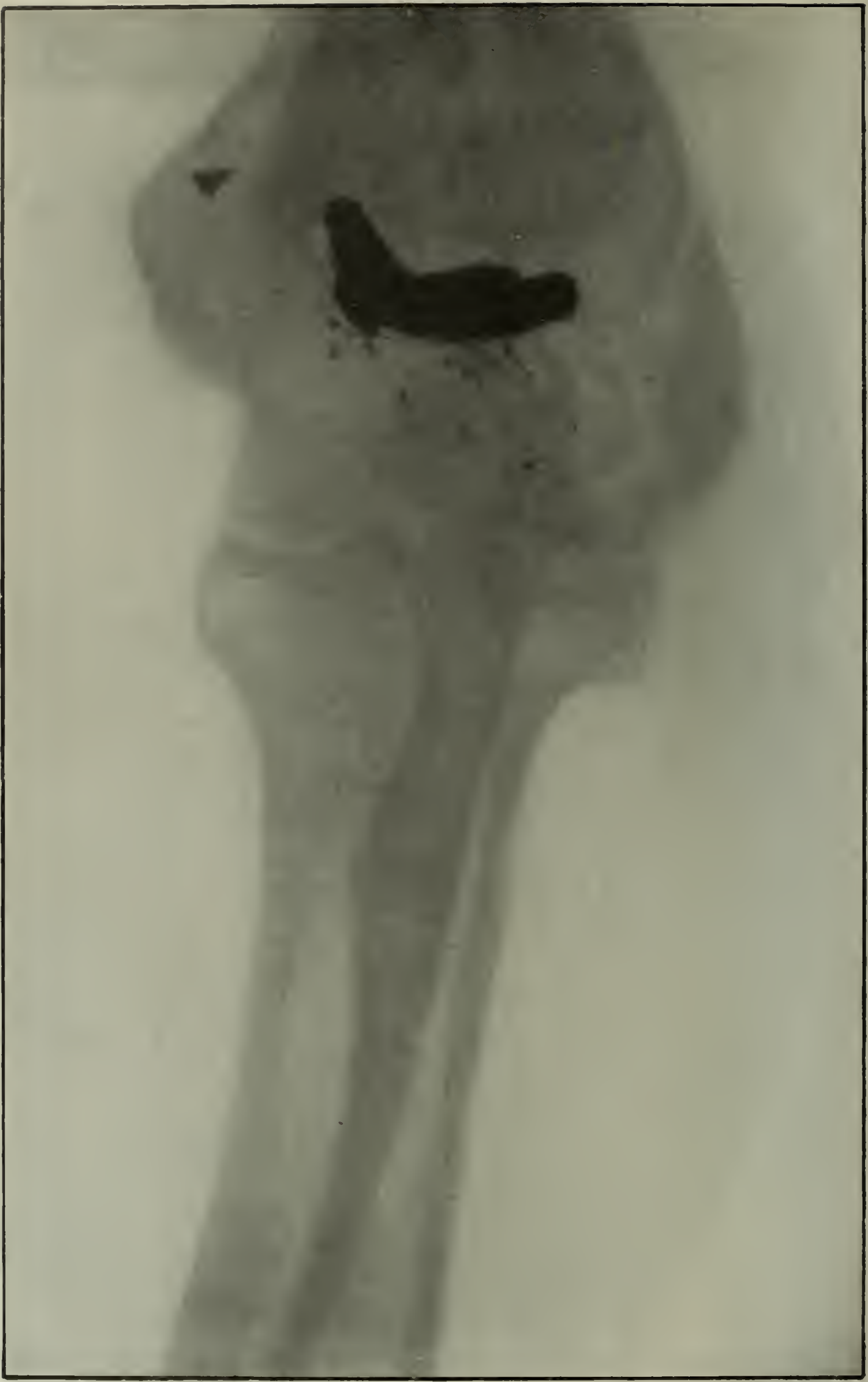
The missile was a fragment of a ricocheted rifle ball, with a part of the lead core carried in a portion of the jacket. The course was from before, backward, striking the humerus in lower third, and leaving particles of lead along its track.

The wound was only slightly infected. Several detached fragments of bone have been removed.

The treatment in such cases is conservative, with management of the infection and without formal search for the projectile.

The results in such cases are favorable with some shortening of the bone.

Plate 15.



RIFLE—PLATE 15.

UPPER EXTREMITY.

Gunshot Fracture of the External Condyle of the Left Humerus, with Lodgment of the Missile.

Wound of entrance, internal and posterior aspect of the arm above the internal condyle.

Wound of exit, none.

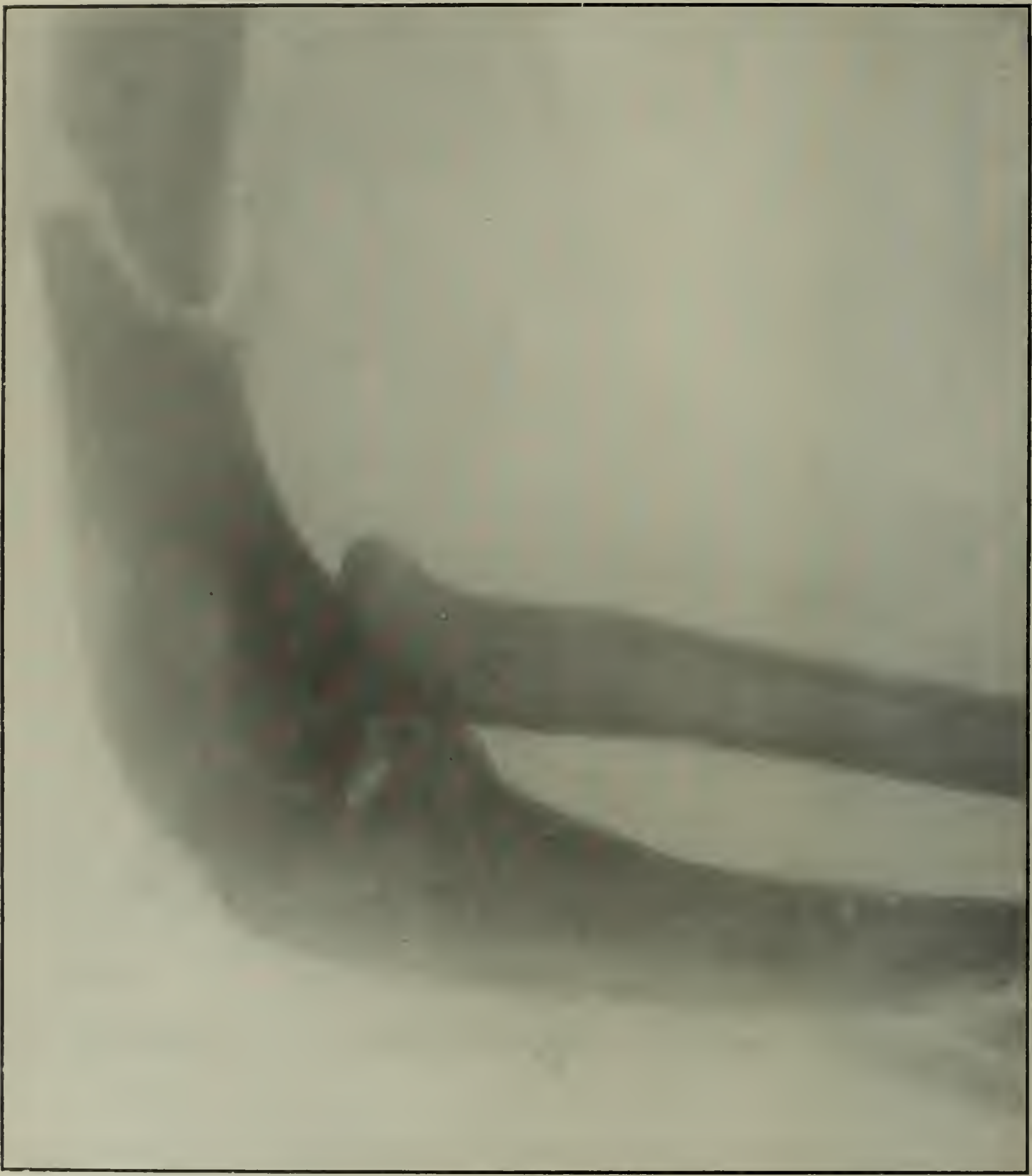
The bullet was greatly deformed by ricochet, with the loss of the greater part or all of its jacket.

The line of contact of the unprotected lead with the bone is marked by the same small fragments of lead almost invariably seen in shrapnel wounds. The ballistic conditions in this case are quite similar to those of a shrapnel wound, as the projectile has struck the bone with low velocity. The very slight displacement of a single large fragment from which the missile is slightly withdrawn indicates that the striking energy was relatively low and that the elastic tissues, stretching around the missile at its striking point, contracted after its energy had been expended and then withdrew the missile from its farthest point of advance.

The treatment in such cases warrants only the interference suggested by infection and the interference of the missile with function.

The results expected are most favorable.

Plate 16.



RIFLE--PLATE 16.

UPPER EXTREMITY.

Gunshot Fracture of the Humerus.

The transverse course of the bullet, striking the posterior wall of the shaft without entering the medullary canal, has fractured the bone transversely, with a tendency toward splitting off a large fragment from the distal fragment.

The bullet under these ballistic conditions of high velocity and not distant range might have bored its way through the cancellous tissue of the epiphysis of the same bone without any fractures.

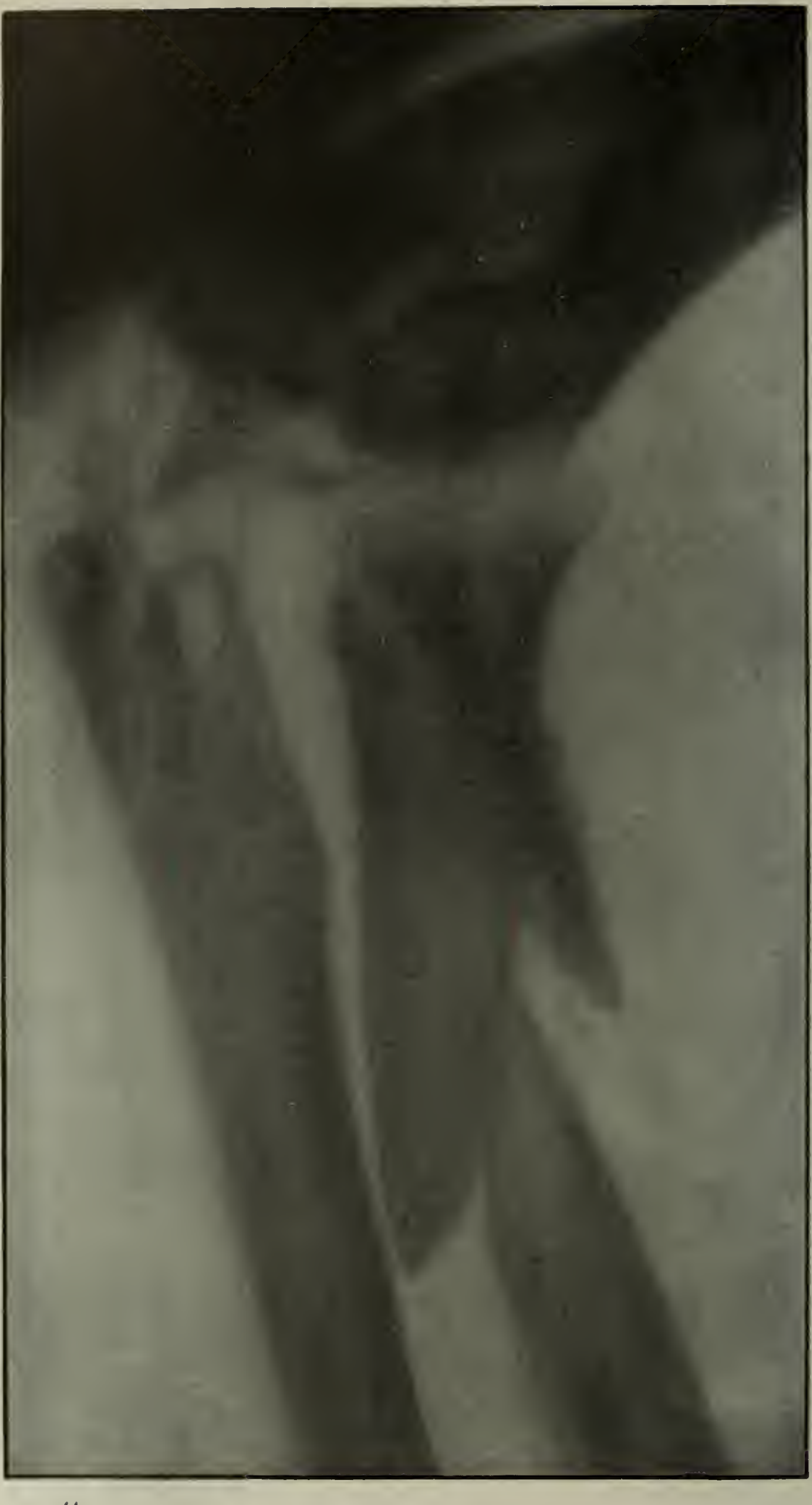
Gunshot Fracture of the Ulna.

The transverse course of the bullet in striking the ulna at high velocity and not distant range has shown a tendency to bore a hole through the bone. A smaller bullet or a larger bone of the same structure might easily have provided conditions to permit this effect. The wounds of exit and entrance in each of these wounds presented almost identically the same appearance.

The treatment in such cases is that of a simple fracture, as there is almost always no infection in such wounds.

Results are favorable.

Plate 17.



RIFLE—PLATE 17.

UPPER EXTREMITY.

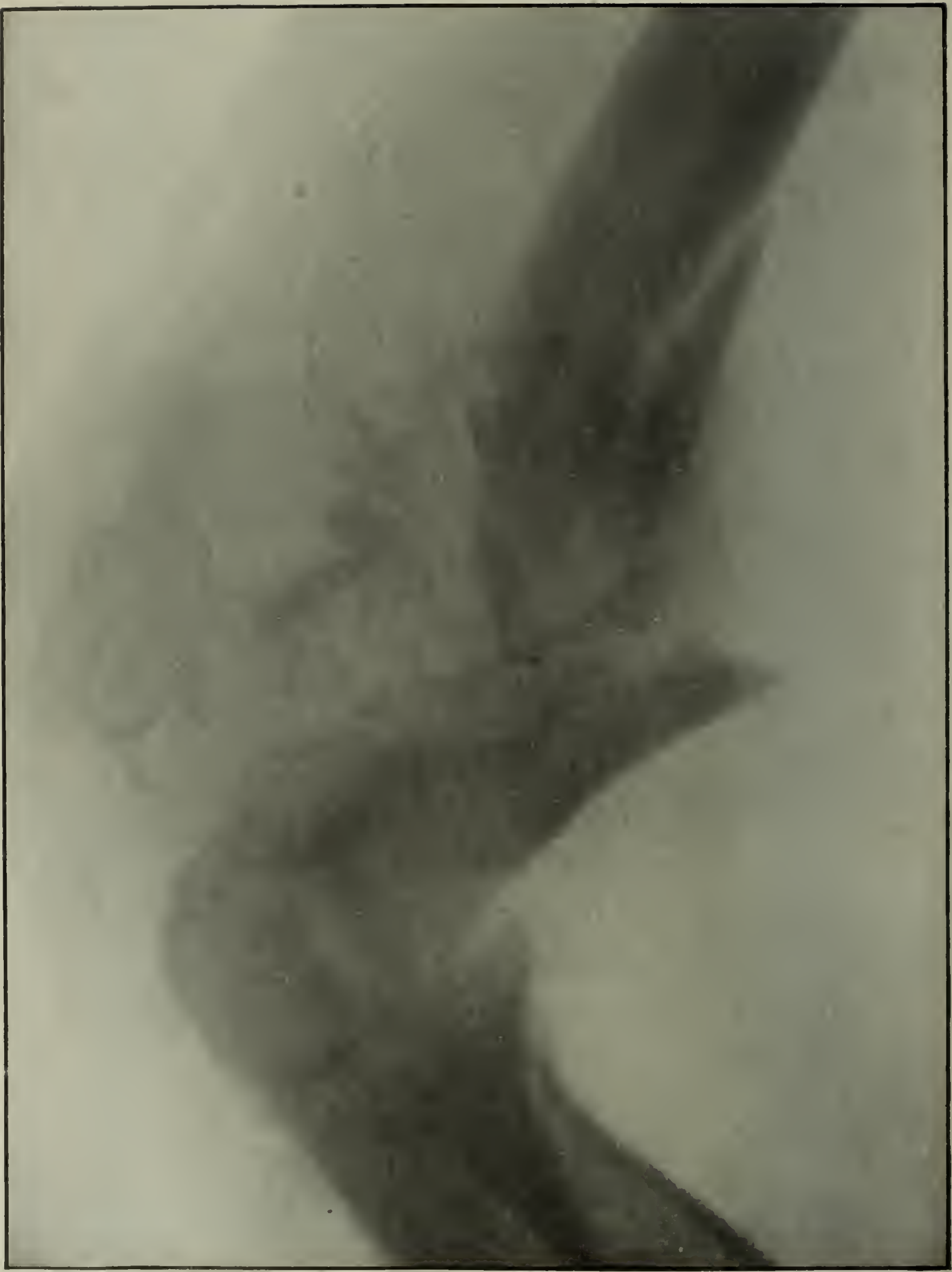
Gunshot Fracture of the Elbow.

The bullet in transverse course and high velocity through both bones of the forearm struck the head of the radius, thus starting several splitting lines of fracture and separating large fragments. Smaller fragments which received some of the energy of the missile have been carried along with it in turn, striking the ulna and carrying away smaller fragments from it and causing the laceration which marks the wound of exit.

Such wounds, with laceration of soft parts and fragmentation of the bone, are prone to infection, against which treatment is directed. The indications to be met are much like those of the wound shown in plates 18 and 19. Excision or immediate methods of bone repair are contraindicated by infection.

Results will depend upon the nature and extent of infection.

Plate 18.



Rifle—Plate 18.

UPPER EXTREMITY.

Gunshot Fracture of the Elbow, without Injury to the Great Vessels and Nerves.

Wound of entrance, posterior to the external condyle.

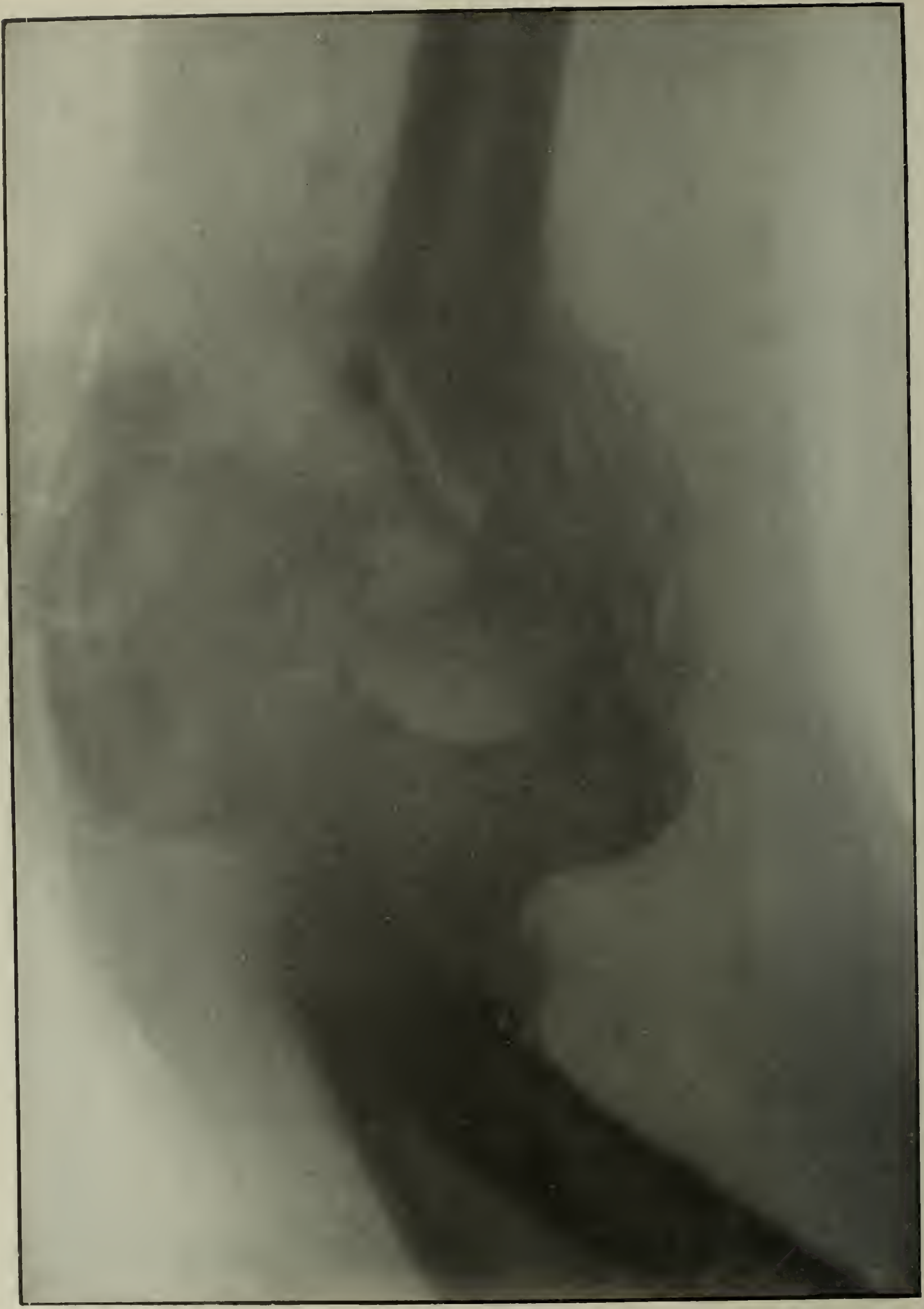
Wound of exit, large laceration in front and above the internal condyle.

The wound is an example of the misnamed "explosive" action of a rifle bullet. The force and direction of the missile, in high velocity, split the bone into many fragments, and, transmitting its energy to some of the fragments, carried them through the skin and caused the large laceration at the point of exit by the simultaneous escape of the bullet and fragments. The wound was so heavily infected, that a cellulitis advanced to the shoulder and to the wrist to such extent that the arm was marked by eminent surgical opinion for amputation. Free incision, drainage, antisepsis and incidental removal of detached fragments controlled the infection and brought about slow resolution. After six months of careful treatment the wound was healed with an ankylosed elbow with normal function of the forearm, except for limited rotation.

Treatment indicated in such cases is always conservative. Infections contraindicate any formal surgical interference. The dangers of infection in such cases are to be risked to avoid amputation.

Results may be considered favorable even with elbow ankylosis.

Plate 19.



Rifle—Plate 19.

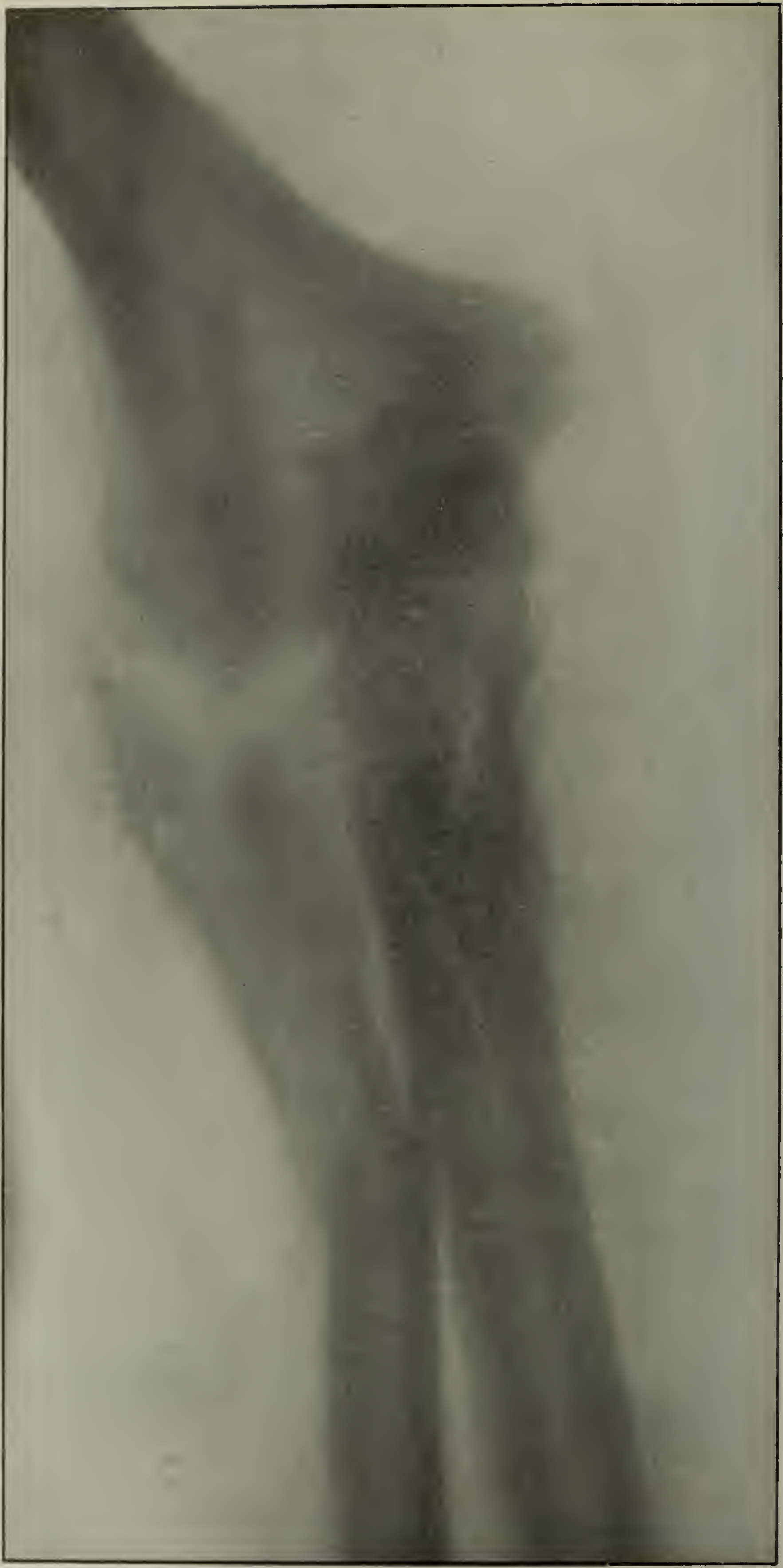
UPPER EXTREMITY

Gunshot Fracture of the Elbow, without Injury to the Great Vessels and Nerves.

This is a plate made of the same subject shown in plate 18, when convalescence was several weeks farther advanced, as is indicated by the removal of fragments and extensive callus formation.

Both radiographs were made after the apprehension of systemic infection had passed; the second plate after an additional number of fragments had been removed.

Plate 20.



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RIFLE—PLATE 20.

UPPER EXTREMITY.

Gunshot Fracture of the Elbow.

Wound of entrance, posterior aspect of forearm internal to and below the olecranon.

Wound of exit, external border over head of radius.

The course of the bullet was diagonally anteroposterior from within outward, striking the posterior border of the upper end of the ulna and passing through the head of the radius, carrying the fragments of the latter before it and lacerating the wound of exit. The energy of impact also fissured the upper end of the shaft of the ulna and fractured the neck of the radius without detaching the large fragments.

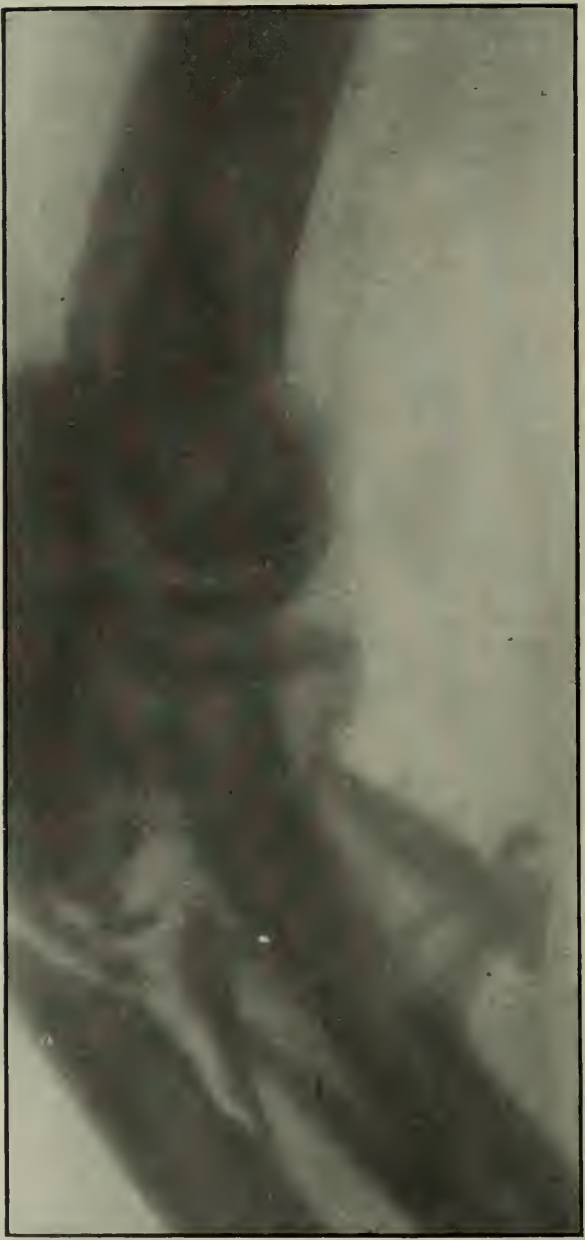
This is the effect of a rifle bullet at short range, or possibly a ricochet shot at mid range.

The emergency treatment is antiseptic dressing with splint immobilization.

The subsequent treatment is conservative, whether the wound is clean or infected. The course of treatment of such an infected wound might extend from four to six months.

NOTE.—As the soldier always escapes the burden of explanation when the wound of entrance is anterior rather than posterior, it should be remembered that the forearm may occupy positions in relation to the body which exposes the anatomically posterior aspect of the forearm to missiles directed toward the anterior surface of the body; and as the wounds of the forearm herein presented are described in the anatomical position, there is no justifiable impeachment of the soldier's valor in an inference that he was shot from behind when the wound of entrance involves the posterior aspect of the forearm.

Plate 21.



RIFLE—PLATE 21.

UPPER EXTREMITY.

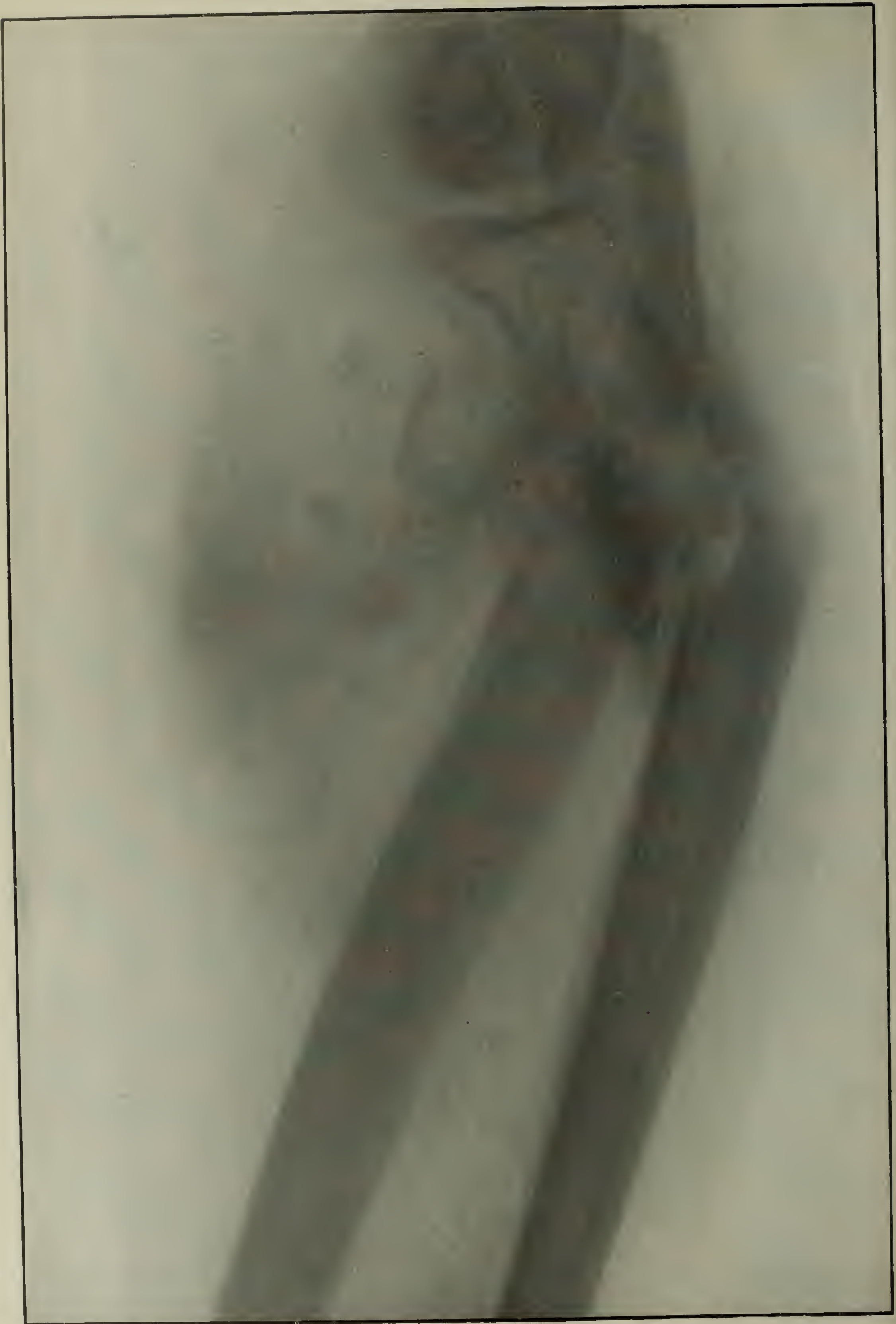
Gunshot Fracture of the Radius and Ulna.

The course of the bullet at short range was transverse through both of the bones, with a splitting effect and without much small fragmentation.

The wound of exit in this case was slightly lacerated, but not very much larger than the wound of entrance.

The treatment should be conservative. Emergency treatment should not include exploration, and nothing but the conventional iodine dressing and splints should be applied.

Plate 22.



RIFLE—PLATE 22.

UPPER EXTREMITY.

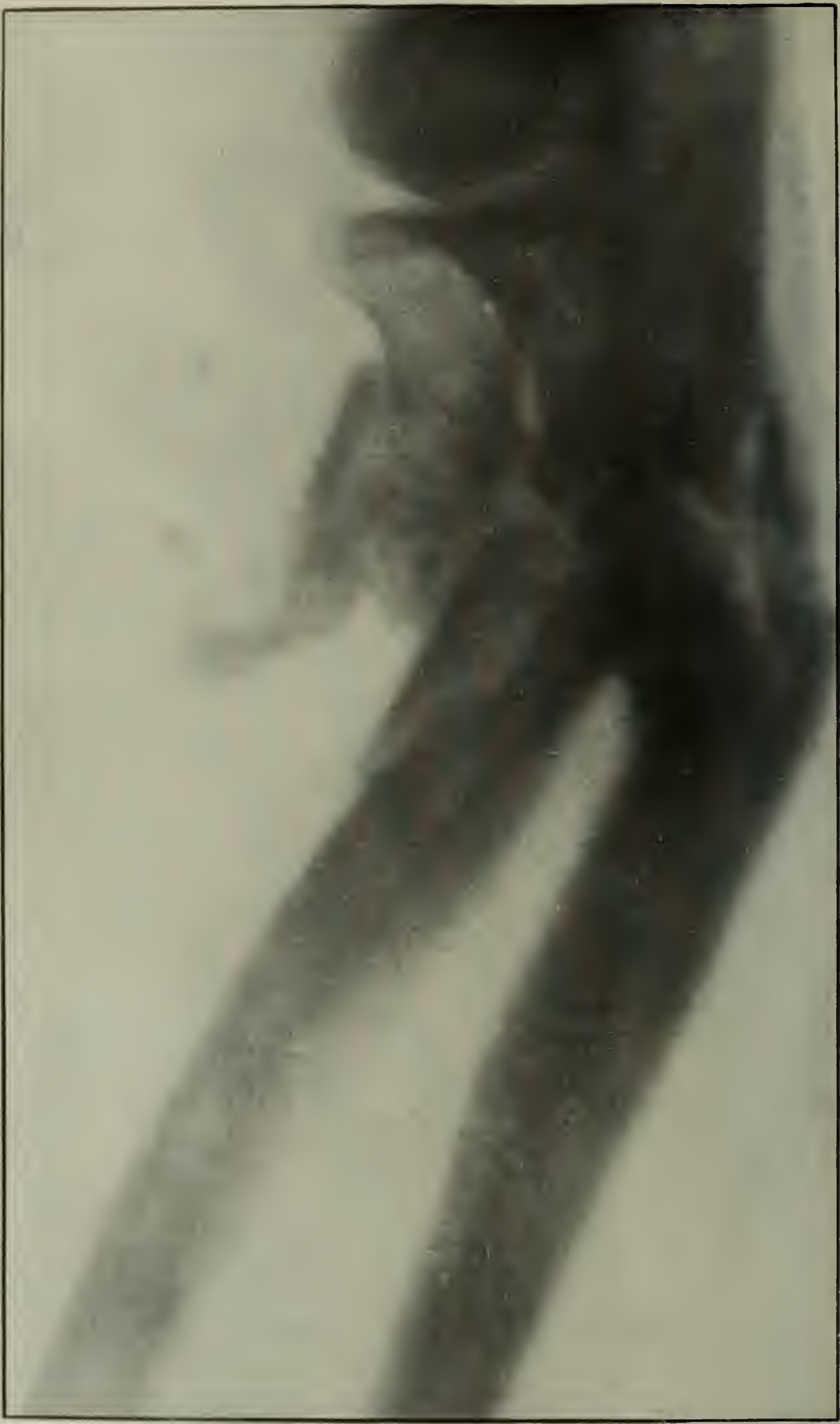
Gunshot Fracture of the Radius and Ulna.

The course of the bullet at short range was transverse through the upper forearm, striking the radius in the center of the shaft and the ulna nearer the border. Several small fragments followed the course of the bullet, but did not emerge with it at the wound of exit to cause a laceration.

The capitellum was next to the photographic plate and the angular line of the radius can be seen crossing the straighter line of the ulna.

Further information is obtained from the examination of another view, plate 23, made of the same subject.

Plate 23.



RIFLE—PLATE 23.

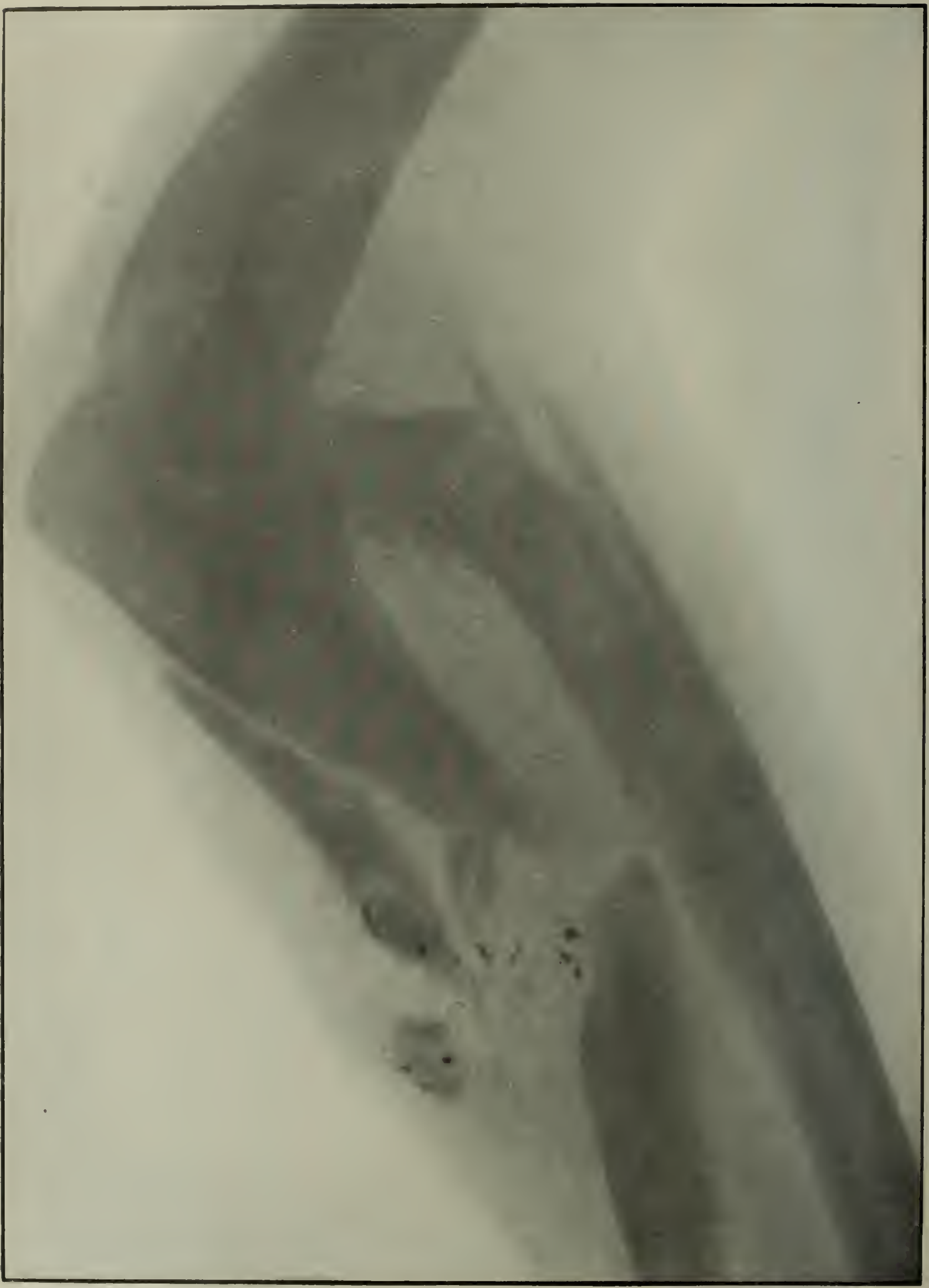
UPPER EXTREMITY.

Gunshot Fracture of the Radius and Ulna.

This plate was made from the wound shown in plate 22, with the arm in greater inward rotation. This position shows the wide separation of the large fragments of the radius.

Emergency treatment in such cases is antiseptic dressing only, without exploration, and with fixation by splints for transportation. The degree of infection determines the subsequent course of conservative treatment, with operative methods for correction of deformity reserved for further stage of convalescence and for best surgical facilities.

Plate 24.



Rifle—Plate 24.

UPPER EXTREMITY.

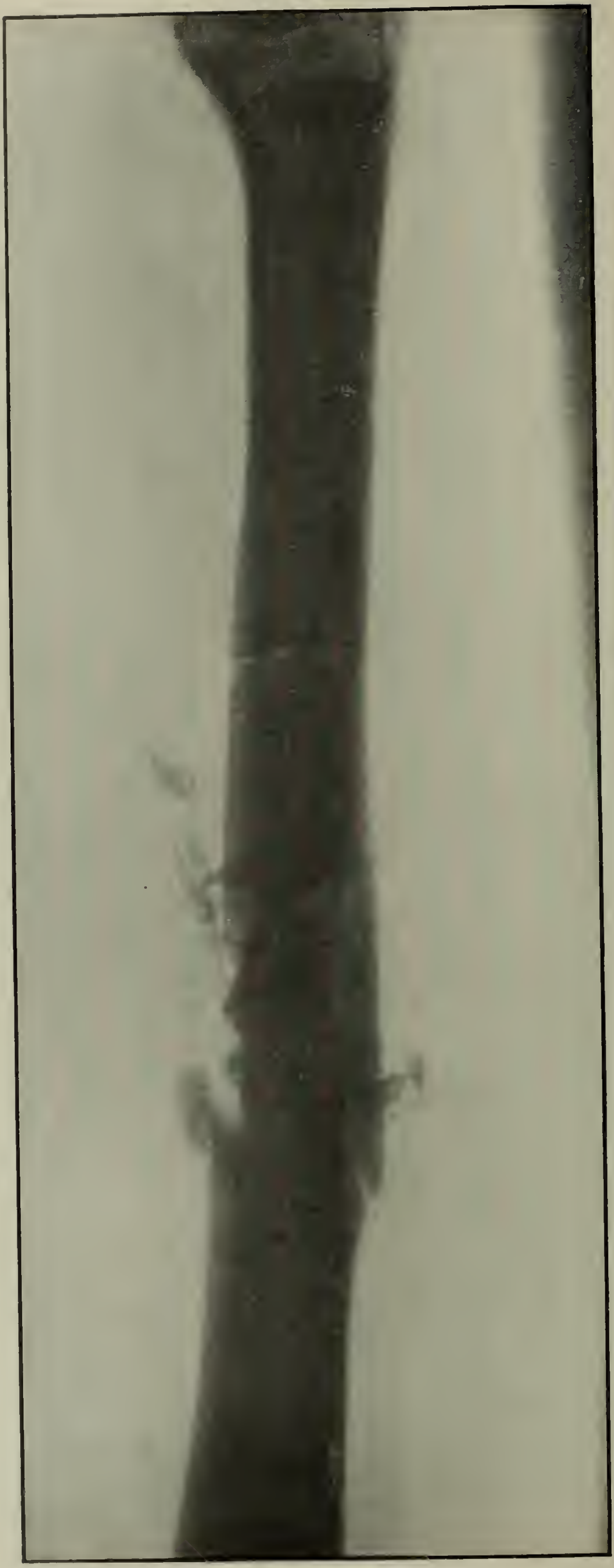
Gunshot Fracture of the Radius and Ulna in the Upper Third of the Forearm.

The course of the projectile was from within, outward and diagonally forward, with a direct impact on the ulna, and a tangential impact on the radius, with several lines of splitting fracture in the latter without detaching fragments. Particles of metal, spattered around the point of first impact, were deposited by the lead core of a bullet, exposed by a torn jacket, which struck the second bone with its jacketed surface.

The treatment is always conservative—meeting indications in case of infection.

Results are good for saving the limb, but not for avoiding deformity.

Plate 25.



RIFLE—PLATE 25.

UPPER EXTREMITY.

Gunshot Fracture of the Radius.

Wound of entrance, posterior surface of forearm over radius above the middle.

Wound of exit, below and in front of wound of entrance.

The course of the ball in mid range was from behind, forward, and slightly downward.

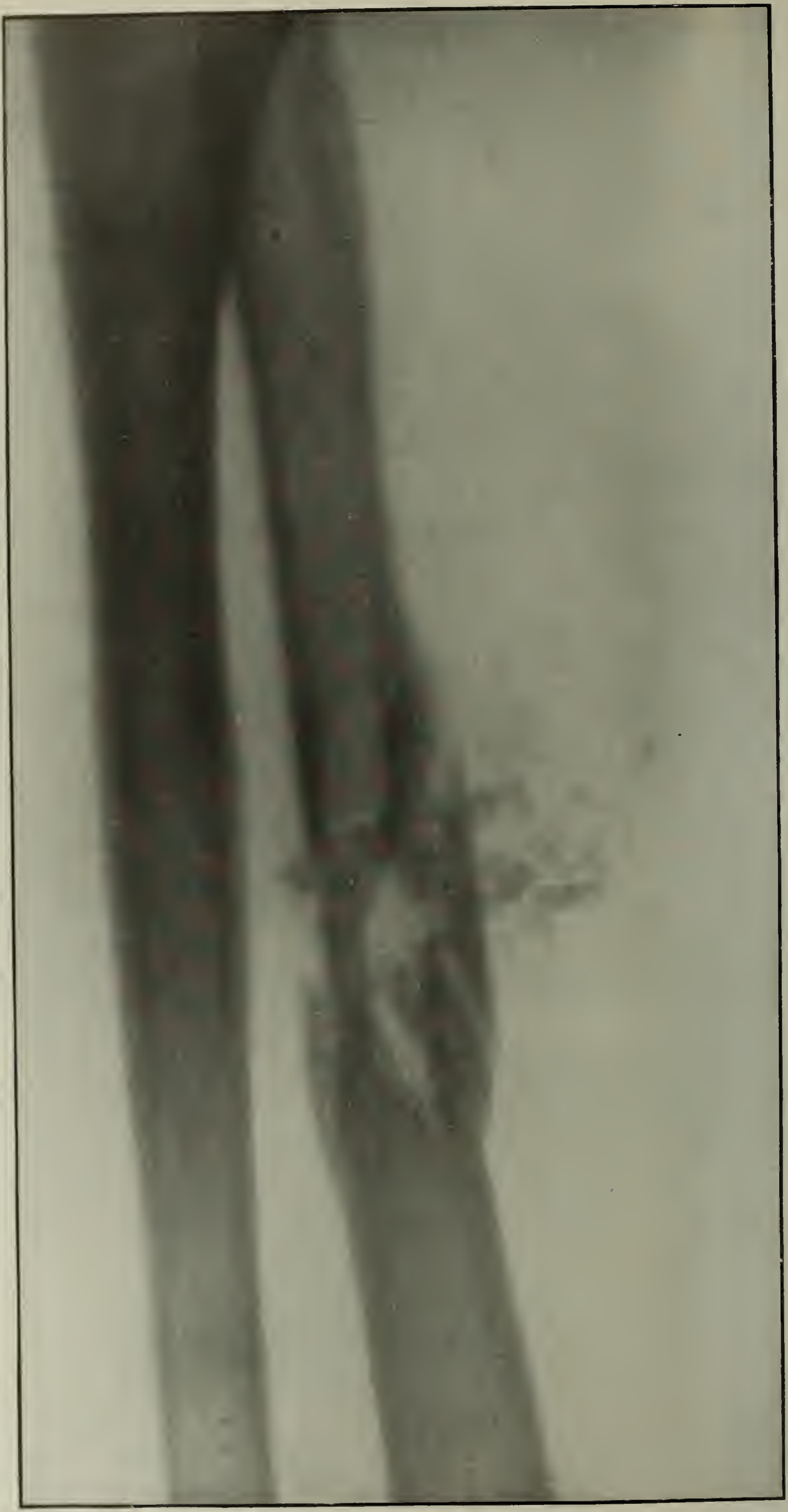
While the images of both bones of the forearm are superimposed, because they both lay in the plane of the projection of the shadow, it is probable that the radius lay nearer the photographic plate, because the head of the radius is shown in clearer outline. The fragments of the fracture can be seen as related to the outlines of the radius.

There is no displacement and only slight fragmentation, so that the bullet must have almost succeeded in making a punctured wound in the radius.

The treatment in such cases is regularly that for simple fracture, as such wounds are almost always aseptic.

The results are uniformly good.

Plate 26.



Rifle—Plate 26.

UPPER EXTREMITY.

Gunshot Fracture of the Radius.

Wound of entrance, midway between radius and ulna and midway between elbow and wrist, anterior aspect of the forearm.

Wound of exit, over radius at point opposite.

The course of the bullet, in the medium velocity of mid range, in piercing the medullary canal has almost succeeded in drilling the bone without splitting off several longitudinal fragments. Small fragments followed the course of the missile, without being energized sufficiently to lacerate the point of exit by escaping with the projectile.

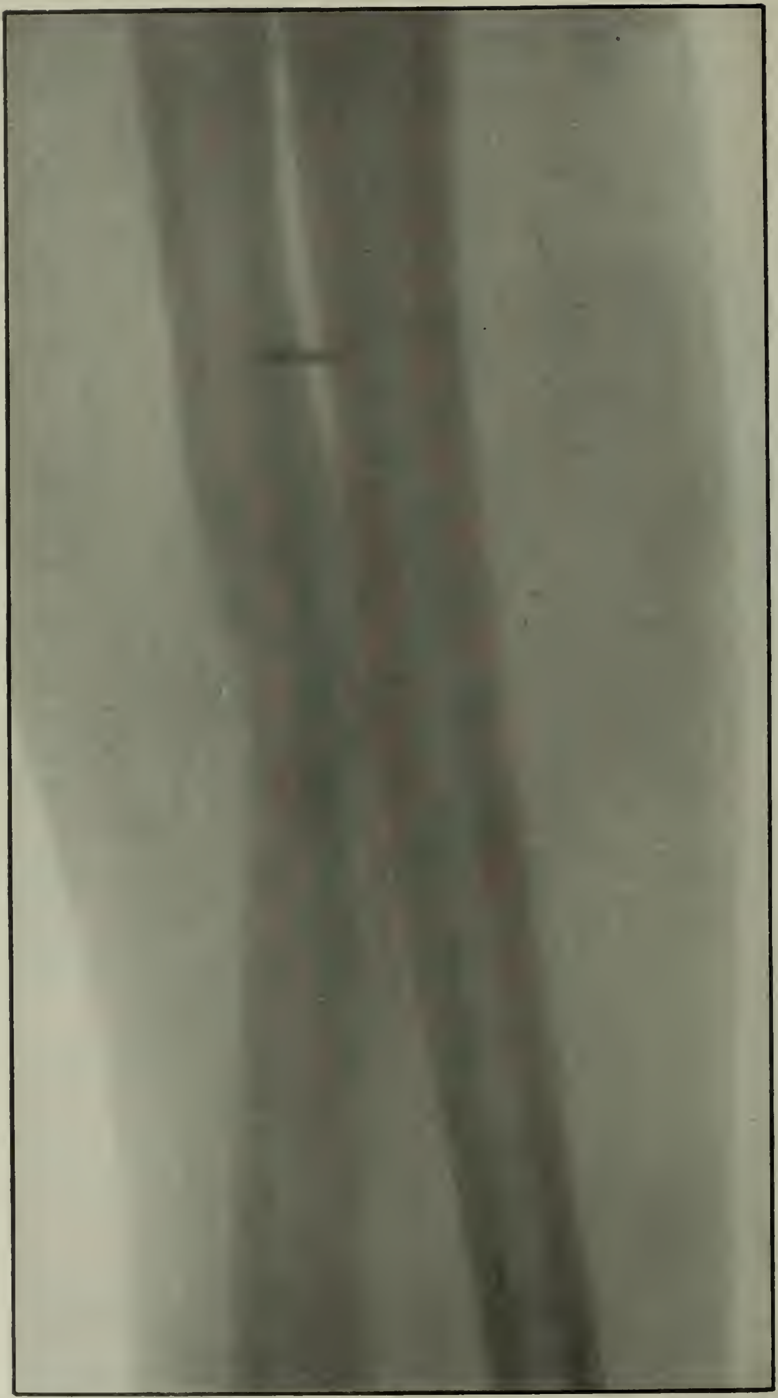
The wound of exit in such cases hardly differs enough from the wound of entrance to be distinguishable. This condition so often obtains that the great majority of perforating rifle wounds of the forearm do not show the blow-out or "explosive" effect which seems to be generally misunderstood as a classic accompaniment.

The bullet was traveling at high velocity of perhaps less than mid range.

The treatment is usually that of a simple fracture, and warrants no interference except in case of occasional infection.

Results are almost always good.

Plate 27.



RIFLE—PLATE 27.

UPPER EXTREMITY.

Gunshot Fracture of the Radius.

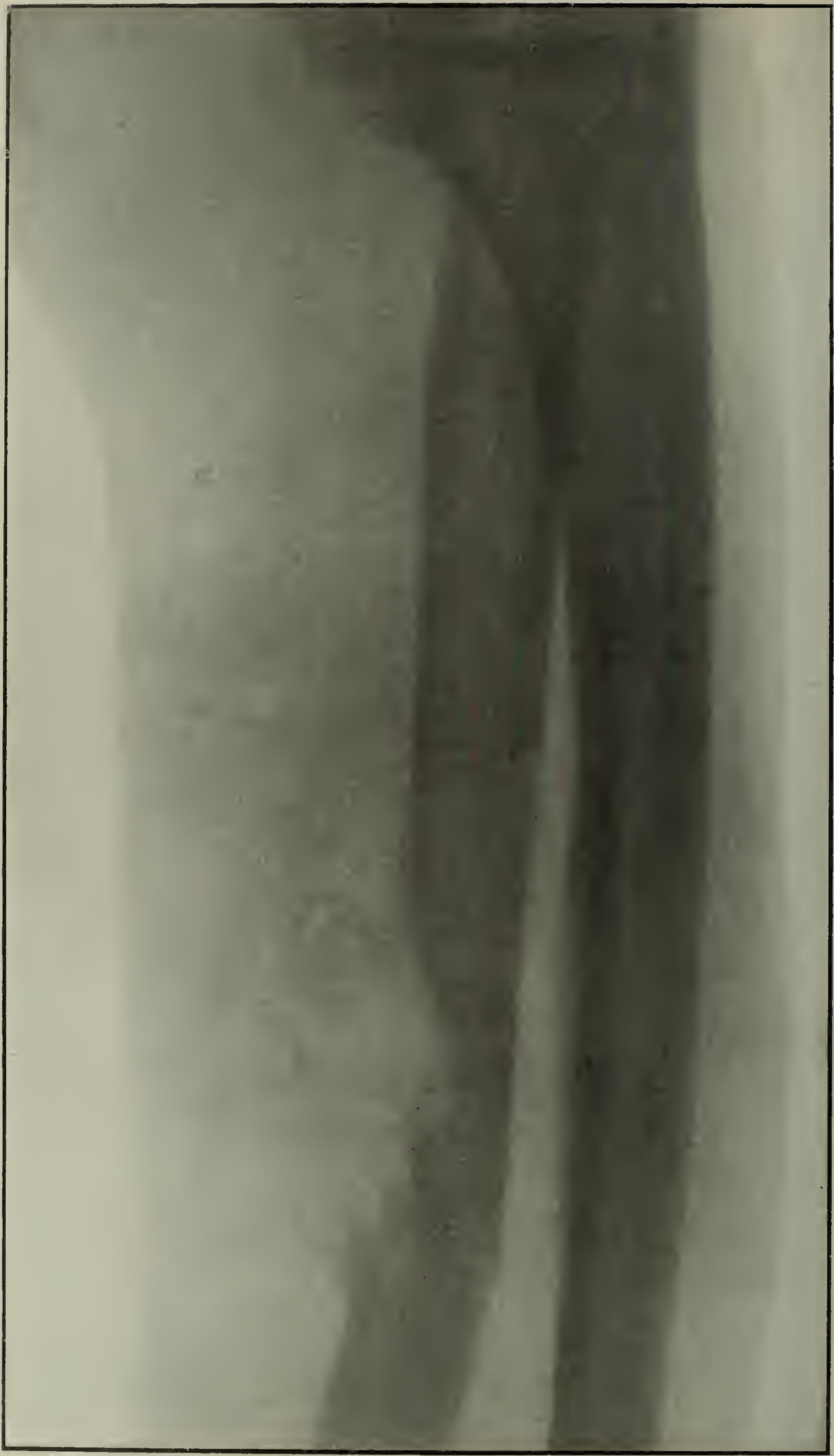
The course of the bullet, at long range, has been diagonally anteroposterior through the shaft, causing only a diagonal fracture.

The plate was made after a two-weeks' convalescence, as is shown by the beginning of callus formation.

The treatment is that of a simple fracture.

Results are good.

Plate 28.



RIFLE—PLATE 28.

UPPER EXTREMITY.

Gunshot Fracture of the Radius.

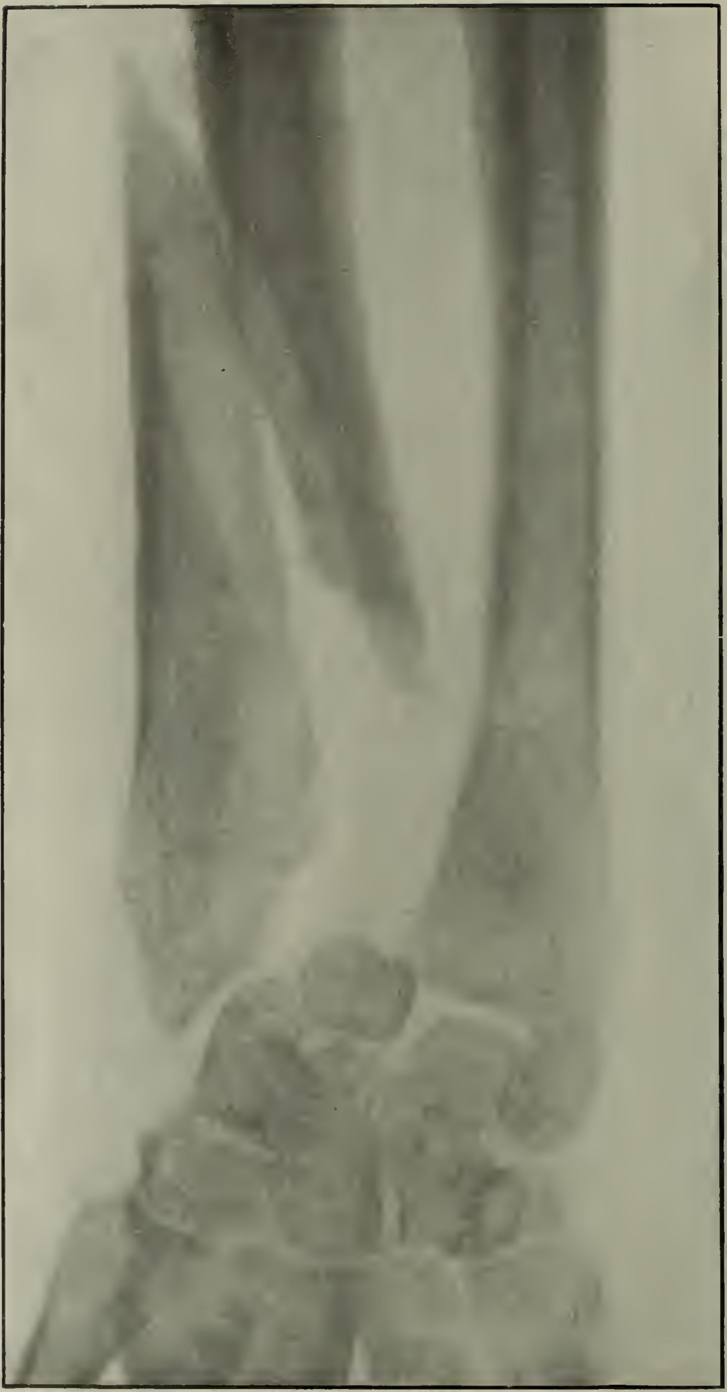
The course of this bullet was anteroposterior and diagonally from above downward through the shaft, punching out one side of the shaft and effecting a diagonal fracture through the bone with only slight displacement. The wound was infected.

The radiograph was taken during the course of treatment, after the several small fragments found by the punched-out portion of the bone were removed. A small drainage tube is in the wound, but the size of the forearm shows that the reaction is very moderate.

The treatment is that of a simple fracture, except for the indications to be met in the control of infection.

Results are good.

Plate 29.



RIFLE—PLATE 29.

UPPER EXTREMITY.

Gunshot Fracture of the Lower End of the Radius.

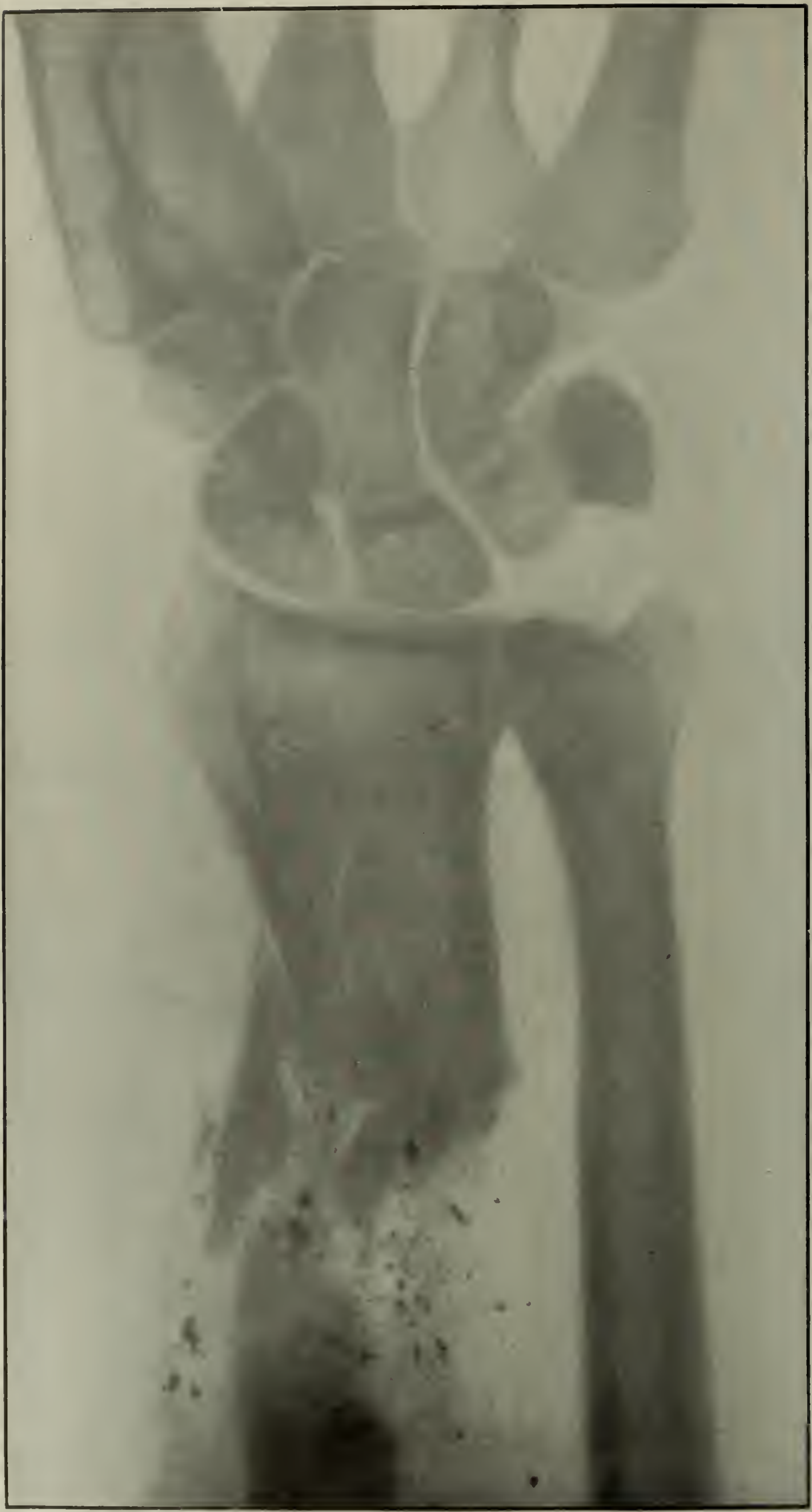
The course of the bullet in long range was diagonally antero-posterior through the ulnar side of the lower end of the bone, with the wound of entrance on the anterior and the wound of exit on the posterior aspect of the wrist. The wound of exit was slightly lacerated by several small fragments driven off from the ulnar side of the radius. These fragments were removed through an incision before the radiograph was made.

The emergency treatment of such cases is only antiseptic dressing and splint immobilization.

When wound is aseptic or after it has closed, a secondary operation for coaptation, with proper facilities available, might be indicated.

The results as to full restoration of joint function are not favorable.

Plate 30.



RIFLE—PLATE 30.

UPPER EXTREMITY.

Gunshot Fracture of the Lower End of the Radius.

The course of the missile was diagonally transverse, striking the radius in its lower third.

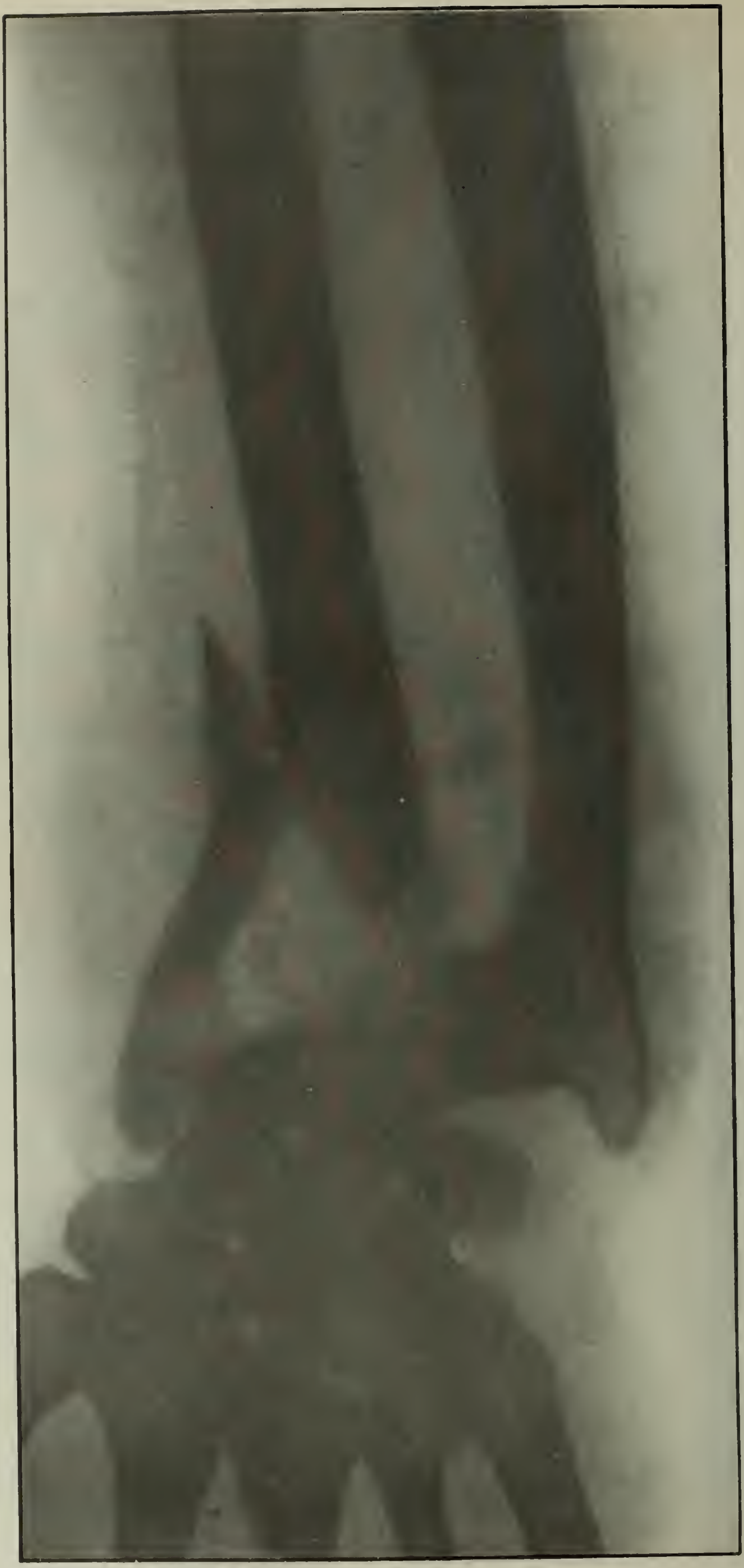
The projectile in this case is unknown, as it might have been either a shrapnel ball or a deformed rifle bullet with a torn jacket, exposing the lead core and marking its course with small particles of lead.

The fissures in the lower fragment and the finer fragmentation at the seat of impact, indicate a great striking energy, that more often resides in the high velocity of a rifle bullet than the low velocity of a shrapnel ball. The wound is therefore classified with rifle wounds.

The treatment is conservative. The course in such cases, without infection, is very favorable, and not unfavorable even with infection.

Results should be good.

Plate 31.



Rifle—Plate 31.

UPPER EXTREMITY.

Gunshot Fracture of the Lower End of the Radius.

Wound of entrance, anterior aspect of wrist, over internal border of radius.

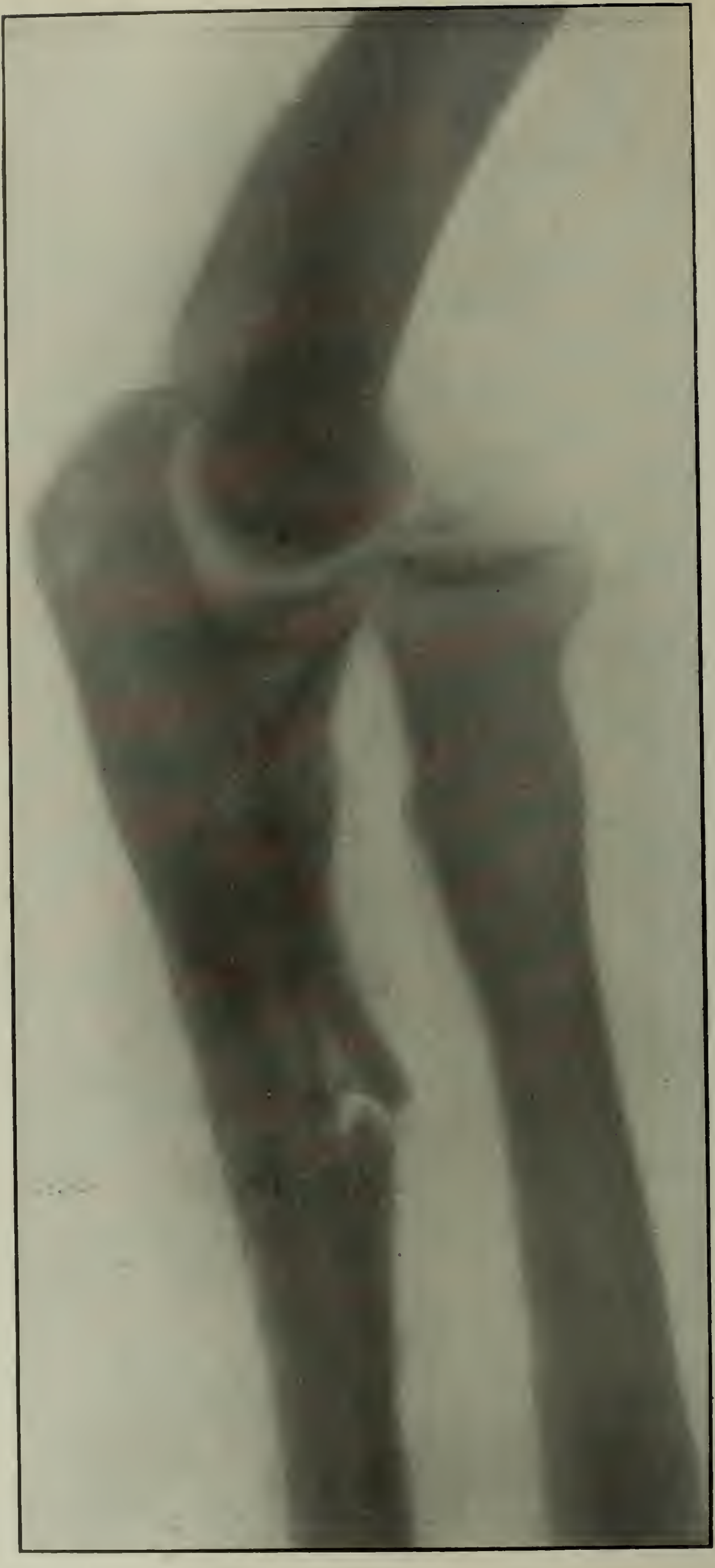
Wound of exit, posterior aspect of wrist between radius and ulna, with laceration.

The range was described as "close"—within a hundred yards—with the bullet in high velocity. The energy of the projectile, imparted to small fragments of cancellous tissue, drove them through the wound of exit, and caused the laceration of the superficial tissues. The wound was infected (swelling of soft parts clearly shown): resolution followed extended treatment, with ankylosis of the wrist and radial displacement of the carpus.

Emergency treatment in all such cases is antiseptic dressing without exploration or manipulation of fragments, and with splint immobilization.

Results are unfavorable as to function, depending upon extent of destruction of tendons.

Plate 32.



RIFLE—PLATE 32.

UPPER EXTREMITY

Gunshot Fracture of the Ulna.

The course of the bullet was transverse through the arm at the junction of the middle and upper thirds from behind the radial border externally to the ulnar border internally, striking the wall of the medullary canal with a punching effect that partly split off short longitudinal fragments and caused transverse and longitudinal cracks, without separation or displacement of fragments.

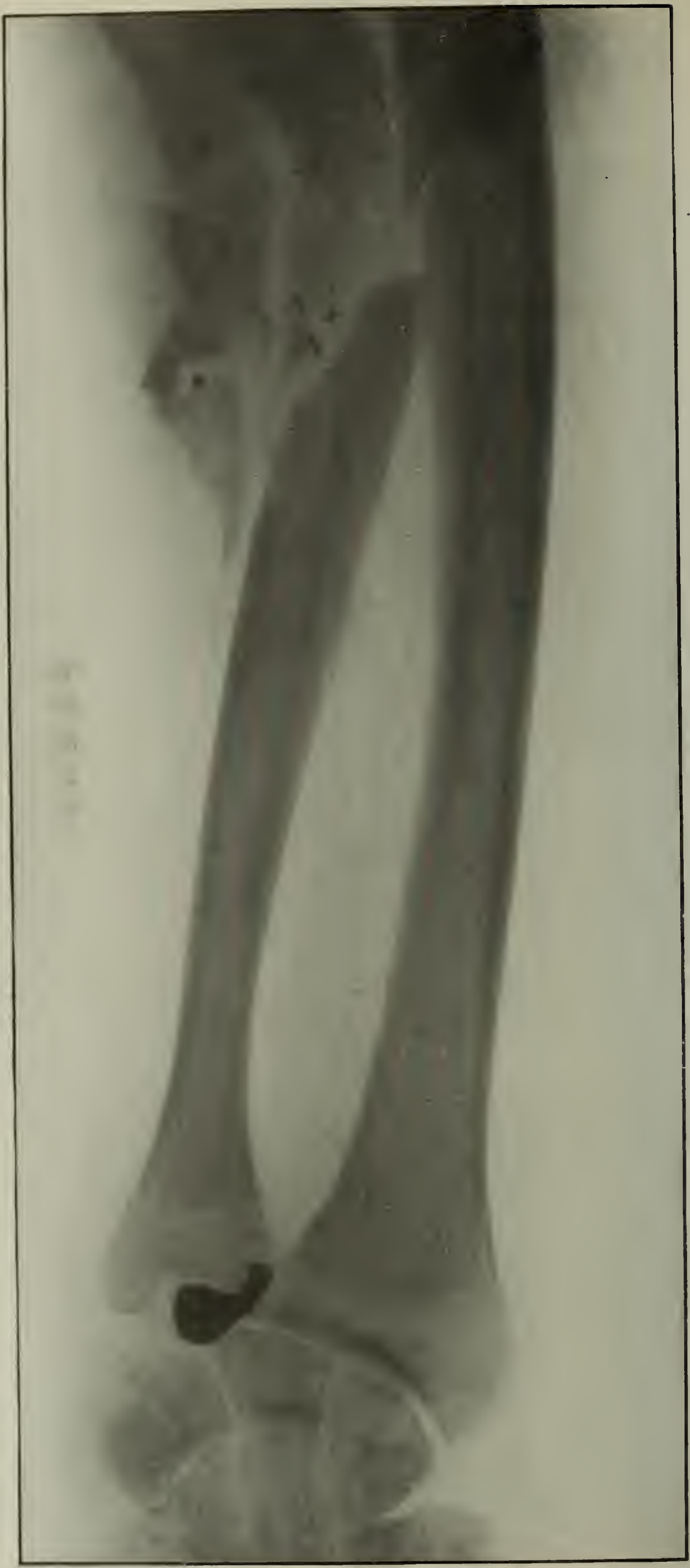
The same ballistic conditions applied to cancellous tissue at the end of the bone would probably have bored through it without fracture.

This effect is generally seen in wounds of small-caliber bullets traveling at reduced velocity of long range.

The treatment is that of a simple fracture.

Results, in such cases without infection, could not be bad.

Plate 33.



RIFLE—PLATE 33.

UPPER EXTREMITY.

Gunshot Fracture of the Left Ulna.

The course of the missile was from within outward, ranging downward to the wrist, by deflection, after striking the ulna in its upper half. The considerable striking energy retained in a small portion of the mass—consisting of only the nose and a little more of the jacket of the bullet, but sufficient to fragment a large section of the bone, and then to traverse more than half the length of the forearm—leaves no doubt that the shot was fired at very close range, and that the bullet was broken on a nearly resisting surface, leaving in the nose of the bullet a striking force equal to that of the entire projectile at long range.

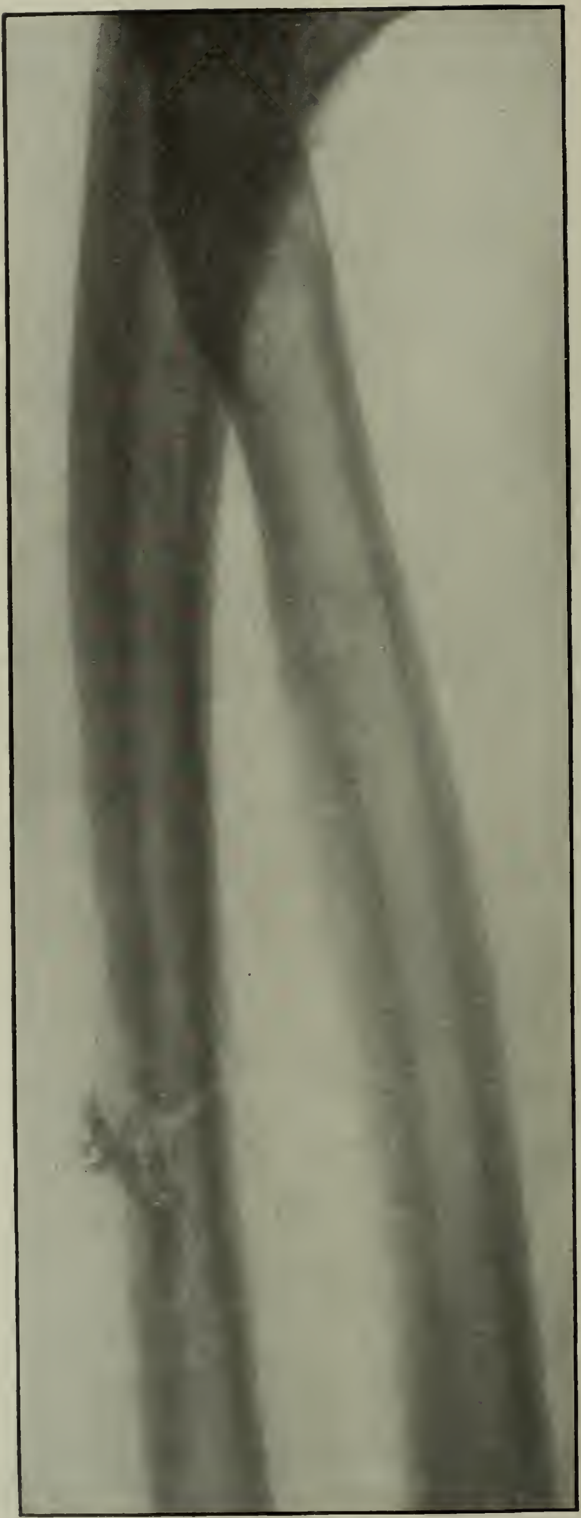
The posterior surface of the forearm is next to the plate, as the distinct outline of the styloid process of the ulna and the posterior border of the articular surface of the radius shows. The radius and ulna are parallel in the most natural position of supination. The normal diameter and sharp outline of the nose of the bullet show it to be next to the plate and on the posterior surface between radius and ulna.

Fragments of the exposed lead core of the bullet have scraped off on the line of fracture in a manner peculiar to shrapnel wounds, but never seen in bullet wounds in which the jacket covers all of the lead core.

The treatment is regularly conservative and without interference, as in this particular wound, which was aseptic.

Secondary treatment may indicate correction of bone deformity.

Plate 34.



Rifle—Plate 34.

UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

The ballistic conditions of the projectile causing the wound shown in this plate are substantially those of the wound shown in plate 32.

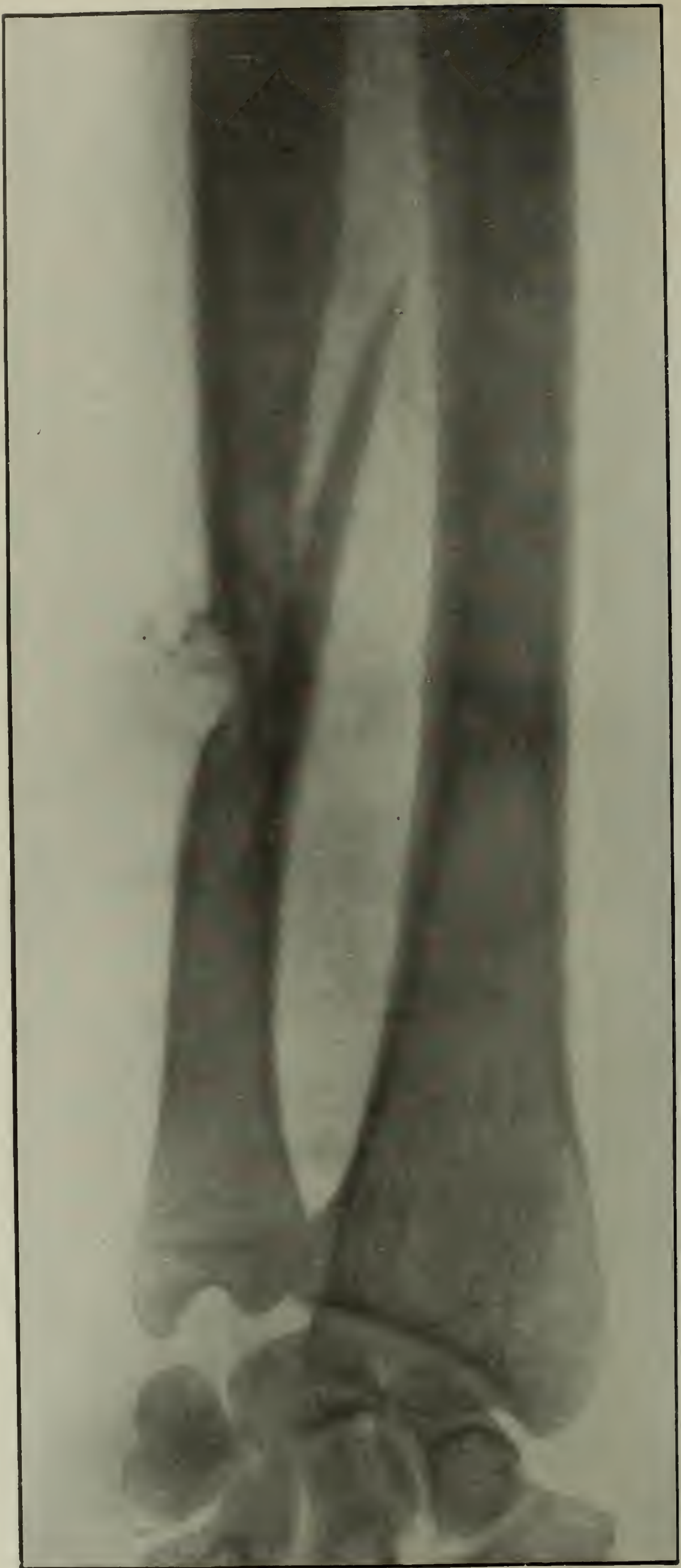
The wound of entrance and exit would be practically the same in chipping off a few small fragments and causing a clean transverse fracture without any displacement.

The bullet at long range has struck the wall of the medullary canal, appearance.

Treatment that of a simple fracture.

Results must be good.

Plate 35.



Rifle—Plate 35.

UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

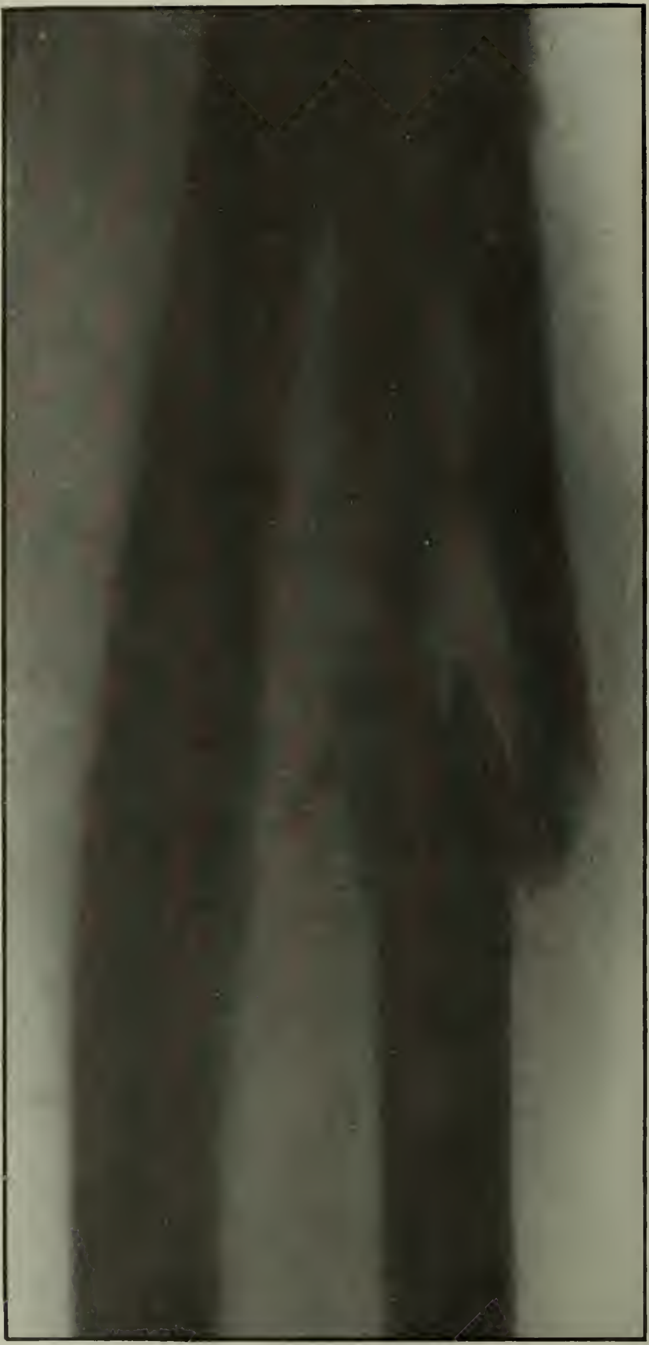
The course of the bullet at long range has been anteroposterior through the middle of the forearm, passing through the side of the shaft, chipping off a few small fragments and causing a long oblique fracture.

The conditions were much the same as those shown in plates 28 and 29, except that the striking energy of the projectile was somewhat greater with the velocity of mid range.

The treatment, without infection, is that of a simple fracture.

Results will be uniformly good.

Plate 36.



82

Rifle—Plate 36.

UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

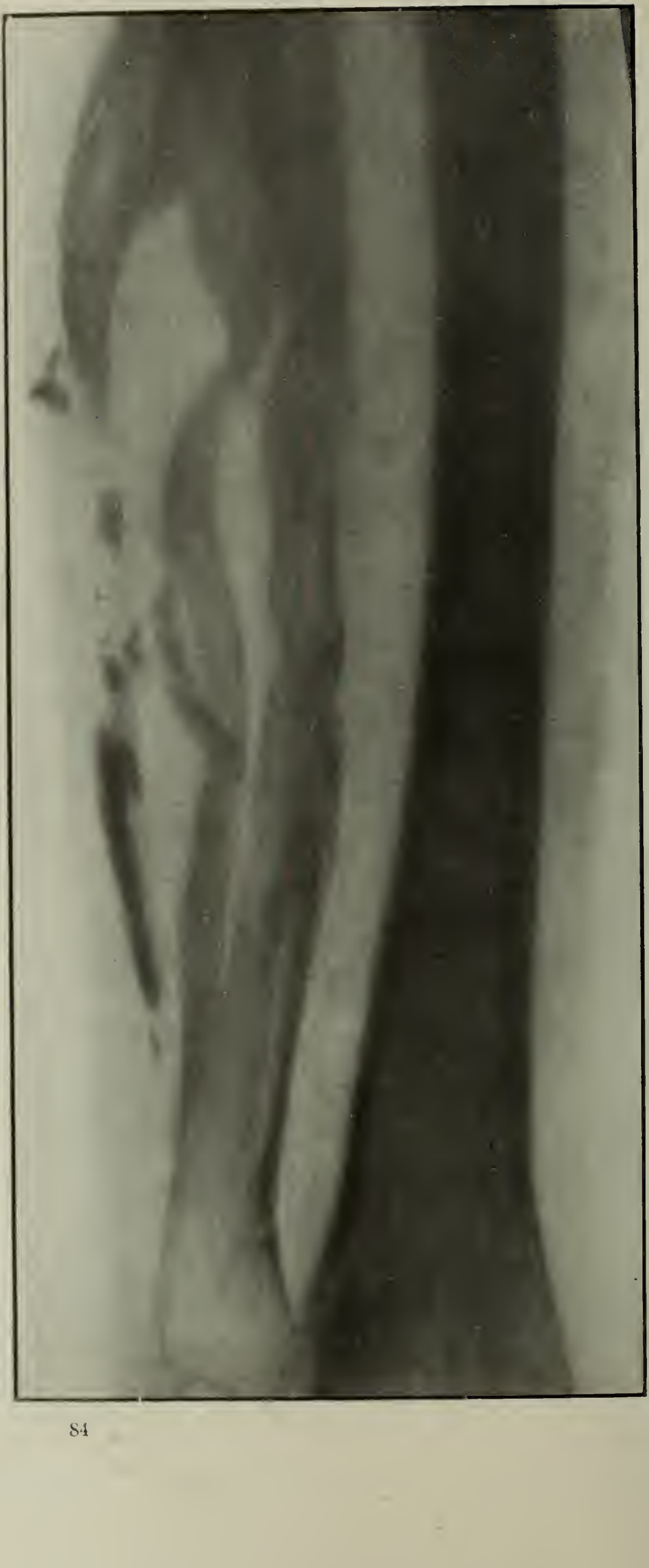
The course of the bullet was anteroposterior through the ulna a little above the middle of the forearm, and fairly through the long axis.

This is a bone effect much similar to those shown in plates 28, 29, and 31, except that this condition is due to the impact of a missile, with a still higher velocity of shorter range, imparting its energy to small fragments of bone, which added their momentum to the destructive force of the projectile.

No large fragments were carried along with the missile to cause any more destruction of tissue in exit than in entrance, so that the skin wounds, under these conditions, are about the same in appearance.

The treatment is conservative and expectant with immobilization. Results in such cases are uniformly good.

Plate 37.



Rifle—Plate 37.

UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

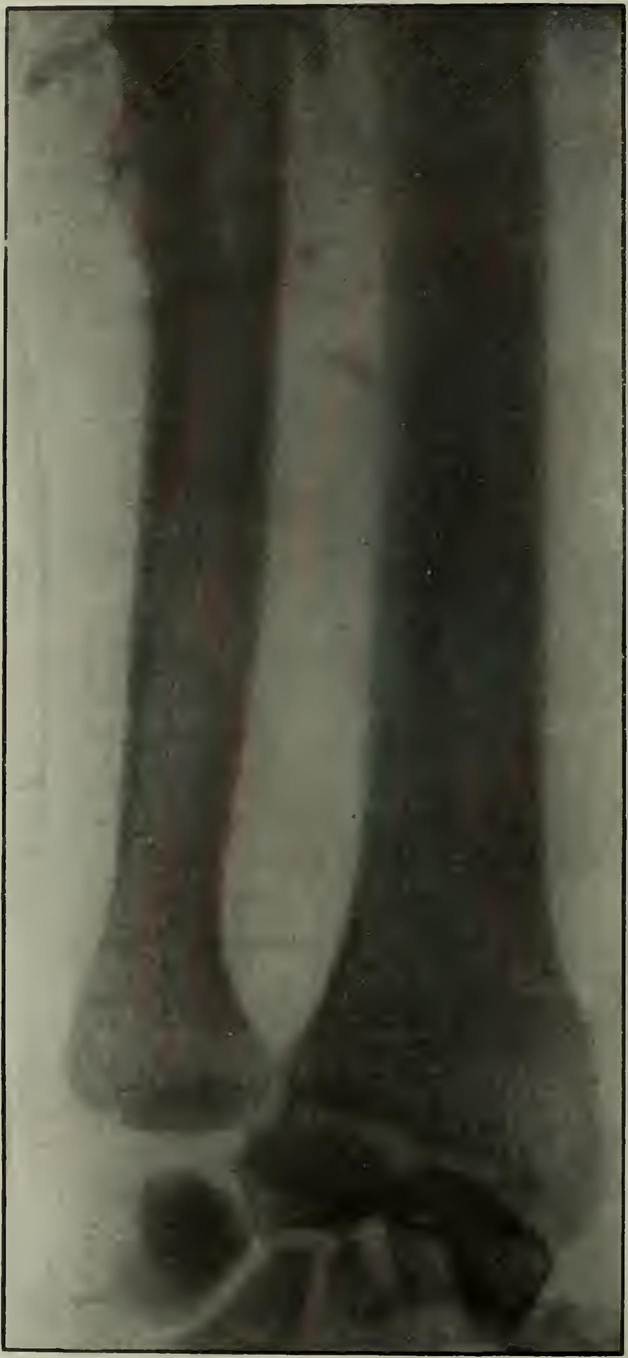
The course of the bullet was in an anteroposterior direction at a high velocity of short range, which, imparting its energy to the fragments, drove some of them through the tissues as "secondary missiles" and caused a laceration of the wound to exist.

The longitudinal fragmentation and splitting indicates a considerable energy of the projectile, which may have been deflected, as its long axis was turned somewhat from the trajectory at the time of impact.

The emergency treatment is antiseptic dressing and splint immobilization.

The subsequent treatment is conservative with the removal of detached fragments and with control of infection as the course indicates.

Plate 38.



Rifle—Plate 38.

UPPER EXTREMITY.

Gunshot Fracture of the Left Ulna.

The course of the bullet was transverse through the middle of the forearm, striking the posterior border of the ulna.

Small fragments were broken from the posterior wall of the medullary canal, without destroying the longitudinal continuity of the anterior wall.

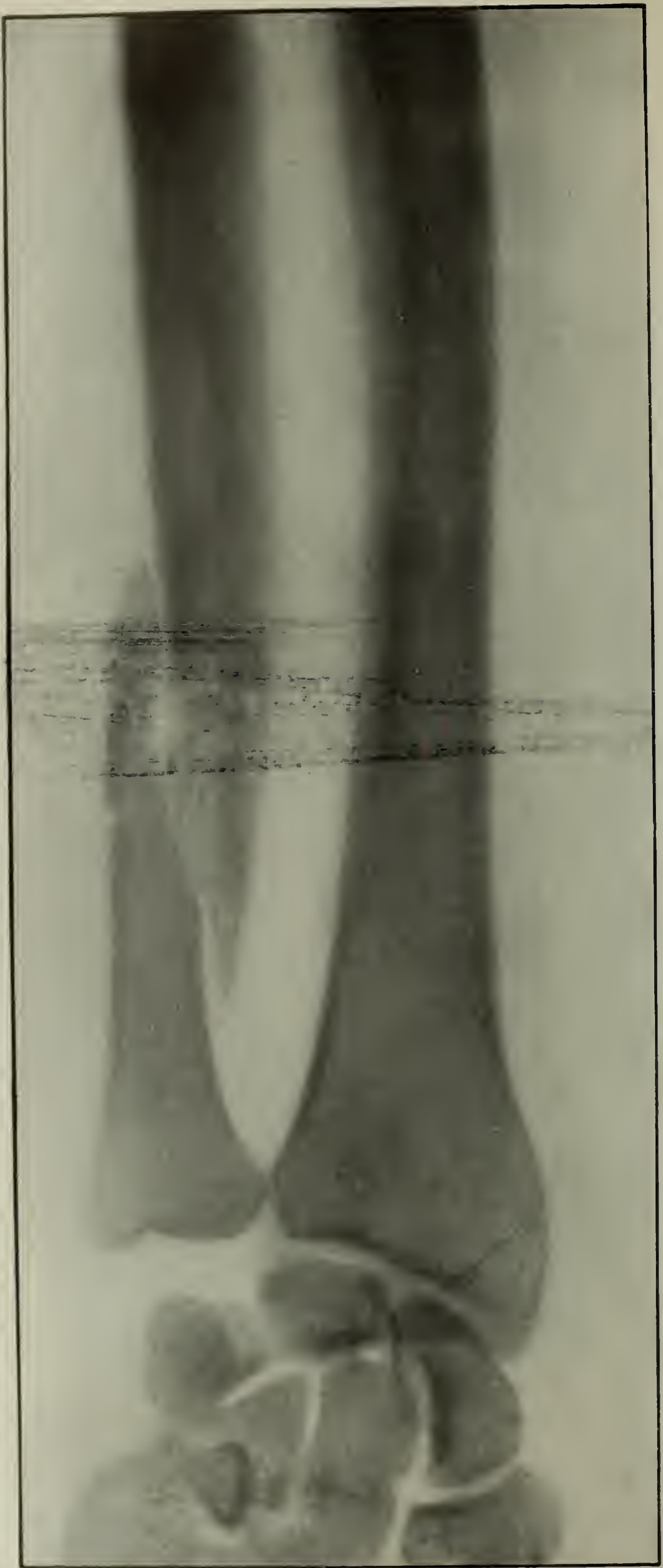
The velocity of the bullet was probably that of midrange, as the striking energy of the impact was fairly great.

The posterior surface of the forearm lay next to the plate.

The emergency treatment is antiseptic dressing and splint immobilization.

The subsequent treatment is that of a simple fracture, as infection is not usual.

Plate 39.



Rifle—Plate 39.

UPPER EXTREMITY.

Gunshot Fracture of the Left Ulna.

The course of the bullet, with the velocity of long range, was anteroposterior through the lower third of the forearm, striking the outer side of the bone. The initial velocity of the projectile was much reduced, as is shown by the tendency to puncture the bone without much fragmentation.

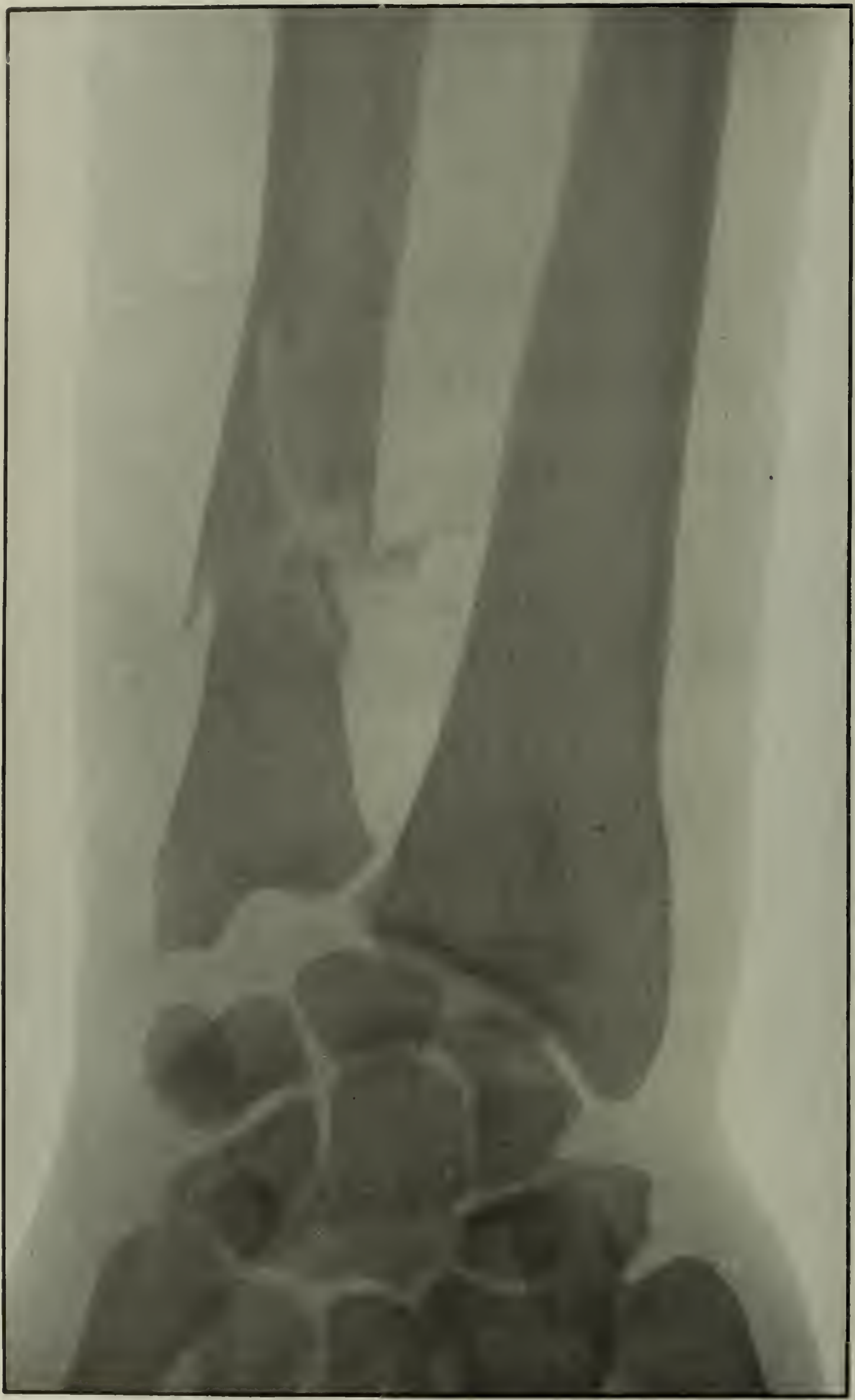
There was no displacement of fragments as a direct result of the impact, although muscular contraction has caused some slight subsequent overriding.

The wounds of entrance and exit were about the same, if not quite similar in appearance.

The emergency treatment is the conventional antiseptic dressing with splint immobilization.

The subsequent treatment is usually that of a simple fracture, as infection in such cases is rare.

Plate 40.



Rifle—Plate 40.

UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

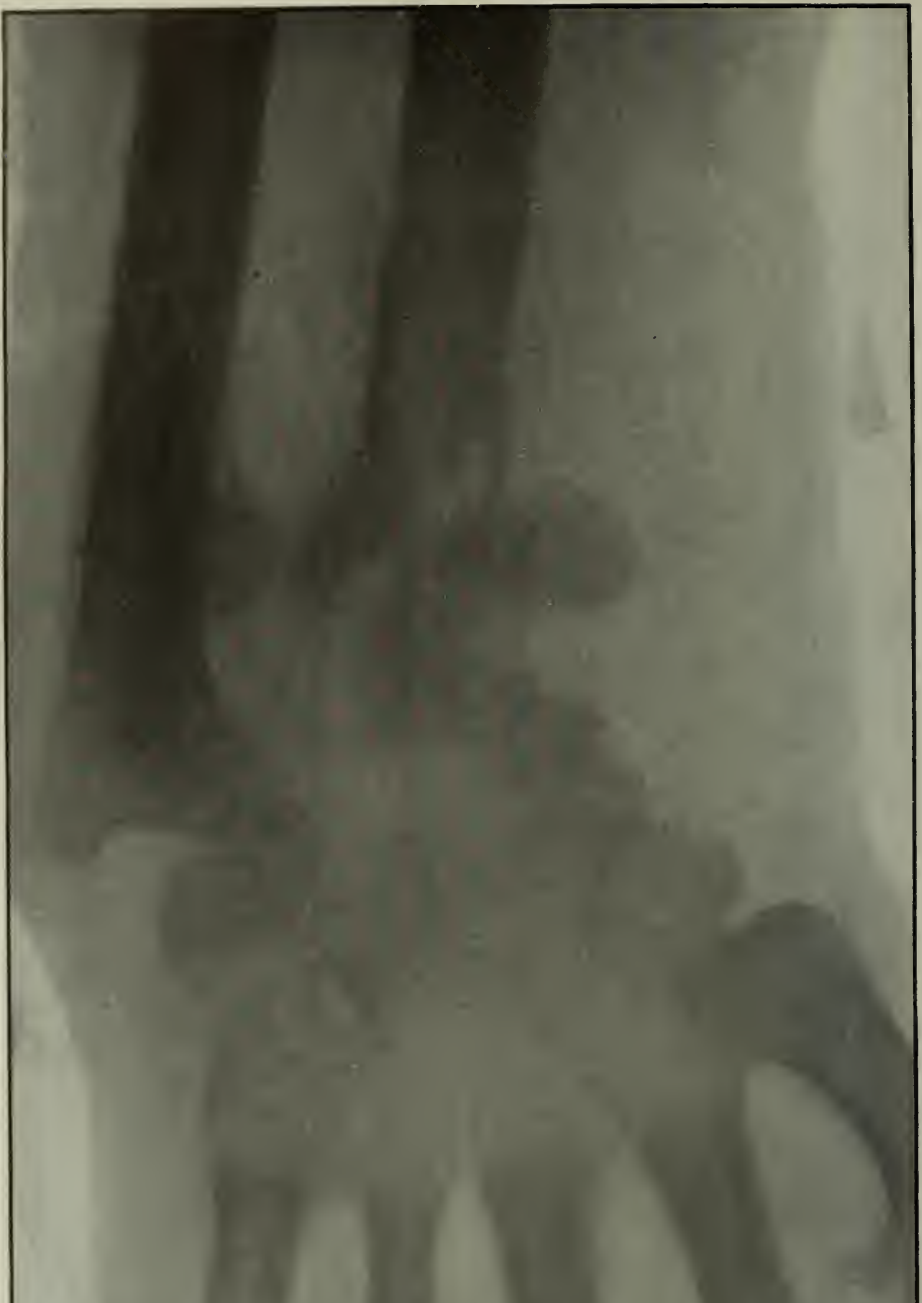
The course of the bullet was obliquely anteroposterior through the lower third of the forearm, striking the radial edge of the bone with a velocity of long range.

The wounds shown in plates 35 and 39 represent conditions similar to those causing this wound, except that the ranges were progressively greater.

In this case the projectile exhibited a punching effect at the point of impact, and, although the lines of force are shown in characteristically divergent fissures, the energy imparted to the fragments—less than in the preceding cases—has not been sufficient to separate or to displace the fragments.

The emergency and subsequent treatment is conventionally conservative, as in the preceding cases.

Plate 41.



Rifle—Plate 41.

UPPER EXTREMITY.

Gunshot Fracture of the Wrist.

Wound of entrance, posterior aspect of forearm over the lower end of the radius, with the bullet ranging forward and slightly downward to the wound of exit and covering with great laceration the anterior aspect of the wrist joint.

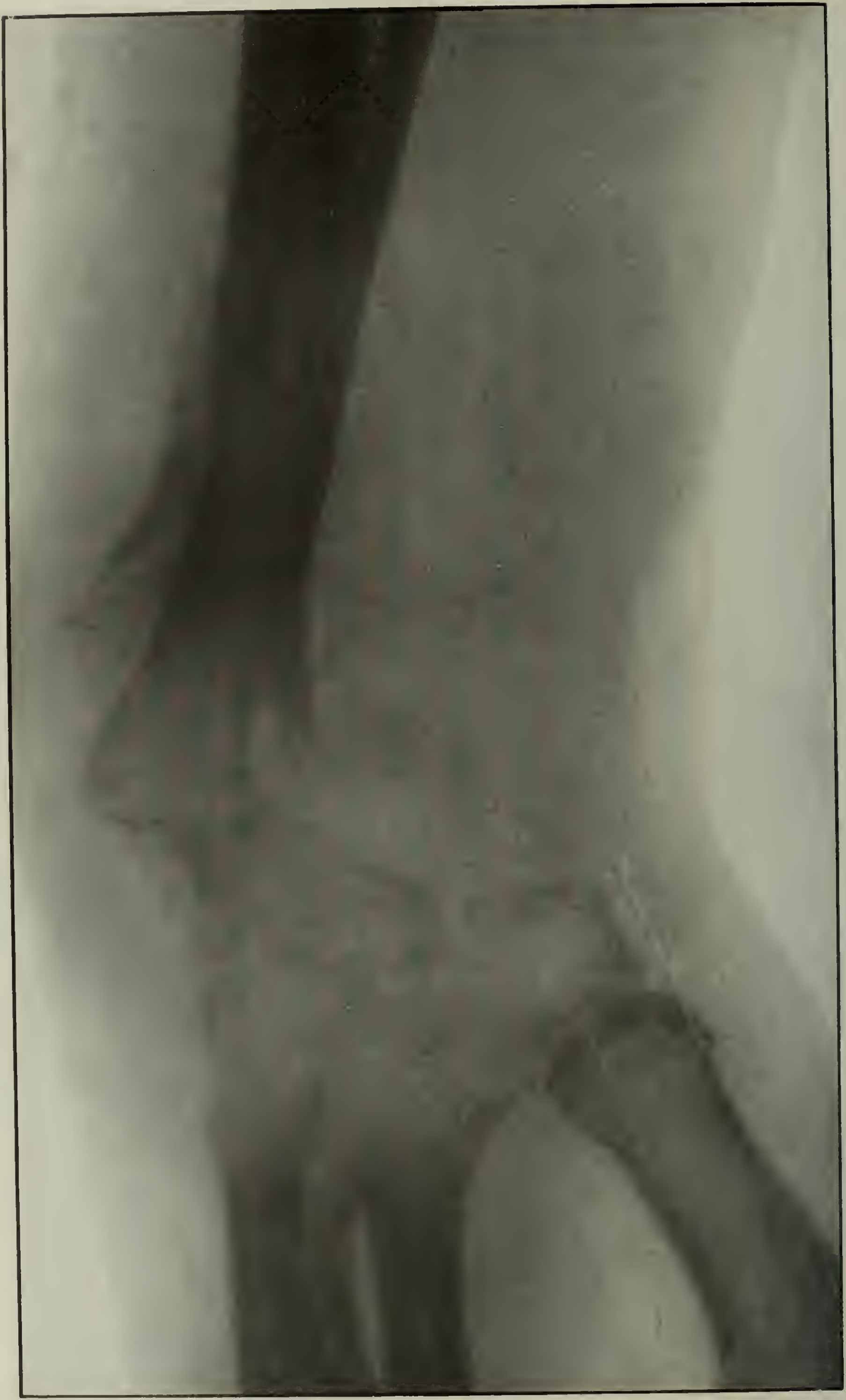
The range was close, and the energy of the high velocity of the missile was imparted to fragments, which, becoming "secondary missiles," emerged with the projectile to cause extensive laceration and destruction of tissue.

The case was received for amputation in the second week, when a grave degree of infection extended in a cellulitis to the elbow. The ulnar nerve and vessels were intact, but the flexor tendons were almost entirely destroyed.

The plate, made after several weeks, when infection was under control and after the end of the radius and fragments of the carpus had been informally removed, shows a rarefaction of the carpus and proximal ends of the metacarpus, due to infection and disuse.

Frequent incisions and extension of drainage, with removal of detached fragments, was continued for several months. The wound was closed in the sixth month, with ankylosis and deformity of the wrist, as shown in plate 42.

Plate 42.



Rifle—Plate 42.

UPPER EXTREMITY.

Gunshot Fracture of the Wrist.

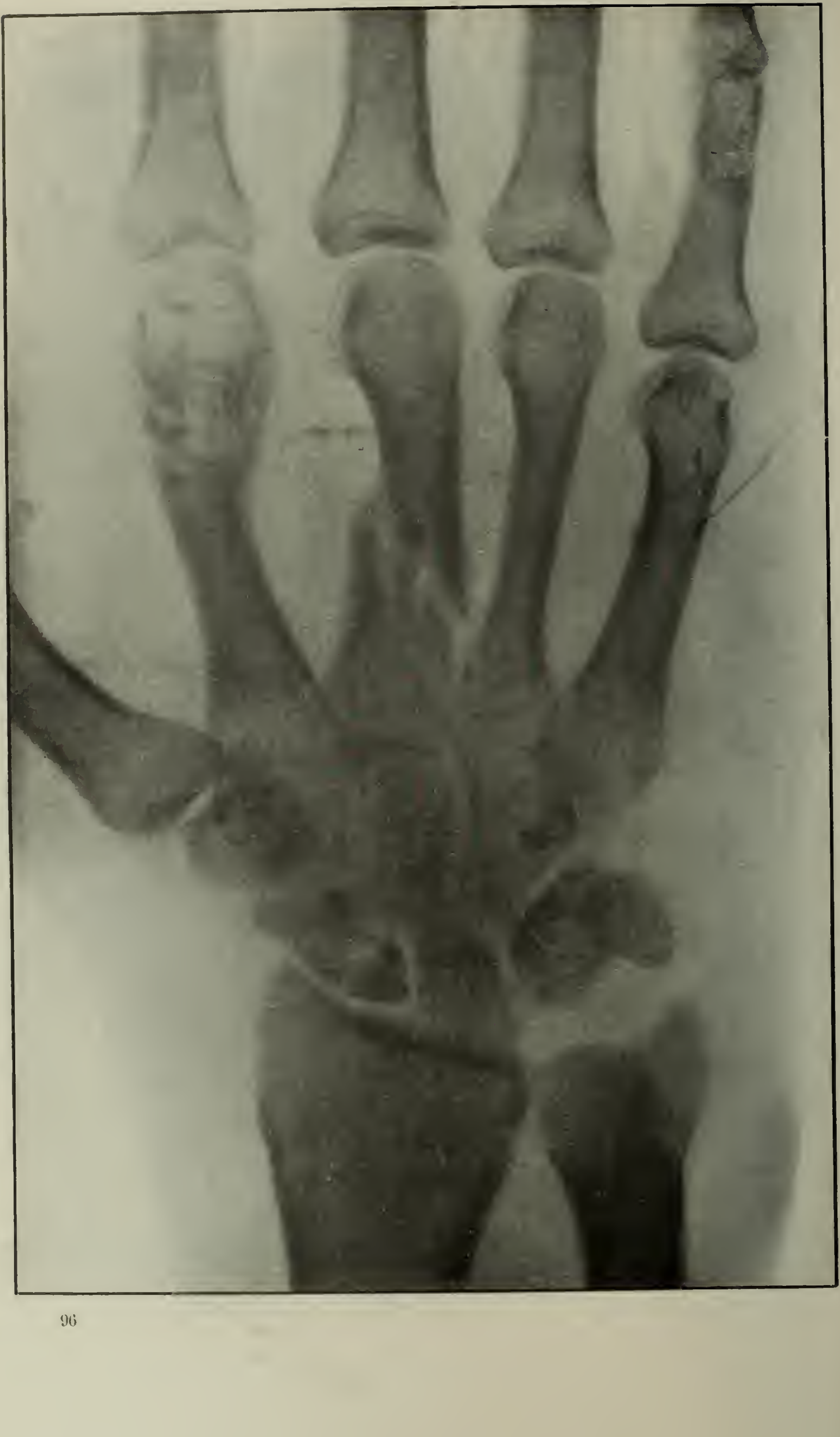
This plate, presenting a lateral view of the wound shown in plate 41, shows considerable deformity of the joint, after four months' treatment, which was even more marked two months later, when the case was discharged with an ankylosis of the wrist joint, contracture of the flexor tendons of the fingers, and slight flexor function of the thumb, permitting apposition with the first finger.

The result, while leaving much to be desired, preserved a function of the hand vastly superior to that of a forearm stump.

The treatment in such cases is always courageously conservative, with amputation only as the extreme measure to save life, with risks of judgment in favor of conservatism.

Corrective measures may be employed after management if the treatment of the infection is successful and when the case passes out of the military category. It is not possible, during a long infection, to maintain better position in such cases.

Plate 43.



RIFLE—PLATE 43.

UPPER EXTREMITY.

Gunshot Fracture of the Metacarpus.

Wound of entrance, inner aspect of the hand over proximal end of the fifth metacarpal.

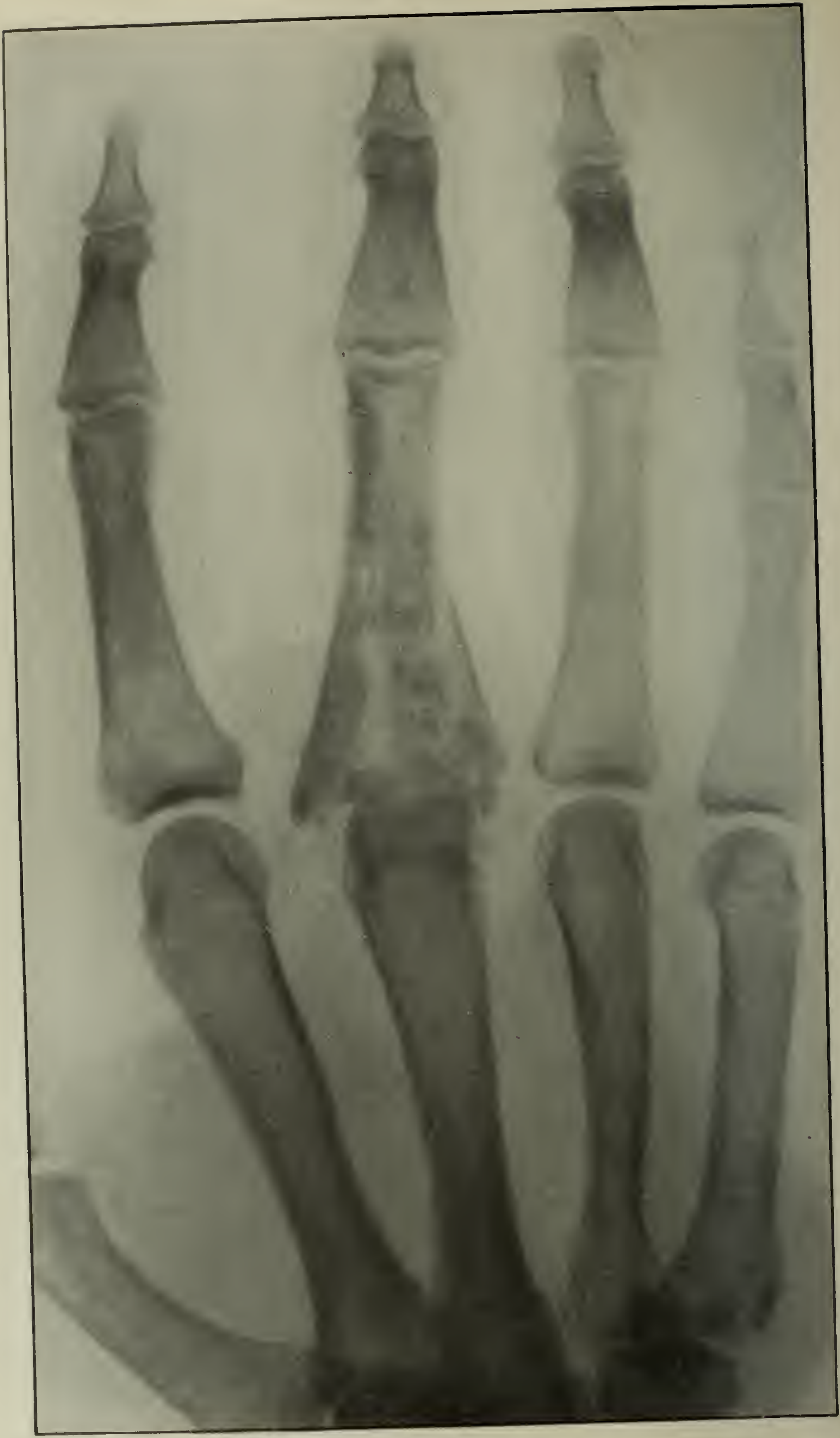
Wound of exit, on the outer border of the hand over the distal end of the second metacarpal.

The velocity of the bullet was in mid or long range, as it displaced no fragments, and as it made a point of entrance and exit about the same in appearance.

The wound was infected, which is more frequently the case in the hand than in the forearm.

The treatment is conservative with free incision and drainage in the management of infection.

Plate 44.



RIFLE—PLATE 44.

UPPER EXTREMITY.

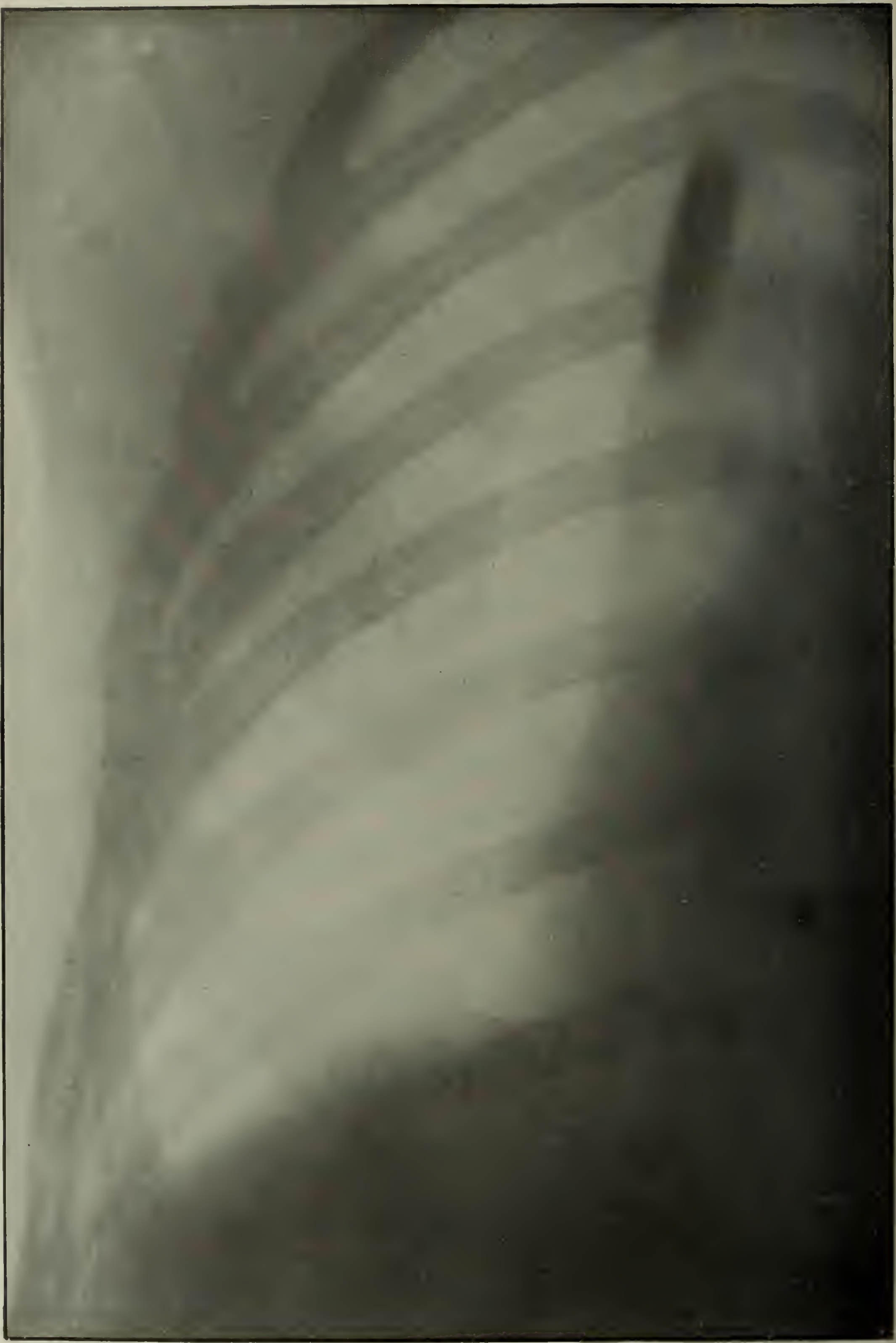
Gunshot Fracture of the Third Phalanx.

The course of the bullet was anteroposterior through the base of the proximal phalanx of the middle finger, with a velocity of long range. It practically punctured the bones and split off a few fragments without displacement.

The wound of entrance would be much the same as the wound of exit, with the latter, but a little larger.

Treatment is conservative.

Plate 45.



RIFLE—PLATE 45.

CHEST.

Penetrating Gunshot Wound of the Chest, with Lodgment of the Projectile Near Posterior Chest Wall.

Point of entrance, pectoral border and fourth rib.

Point of exit, none.

The distinct shadow of the angle of the ribs shows that the posterior chest wall was next to the photographic plate, and that the larger and less distinct outline of the anterior portions of the upper ribs was farther from the plate.

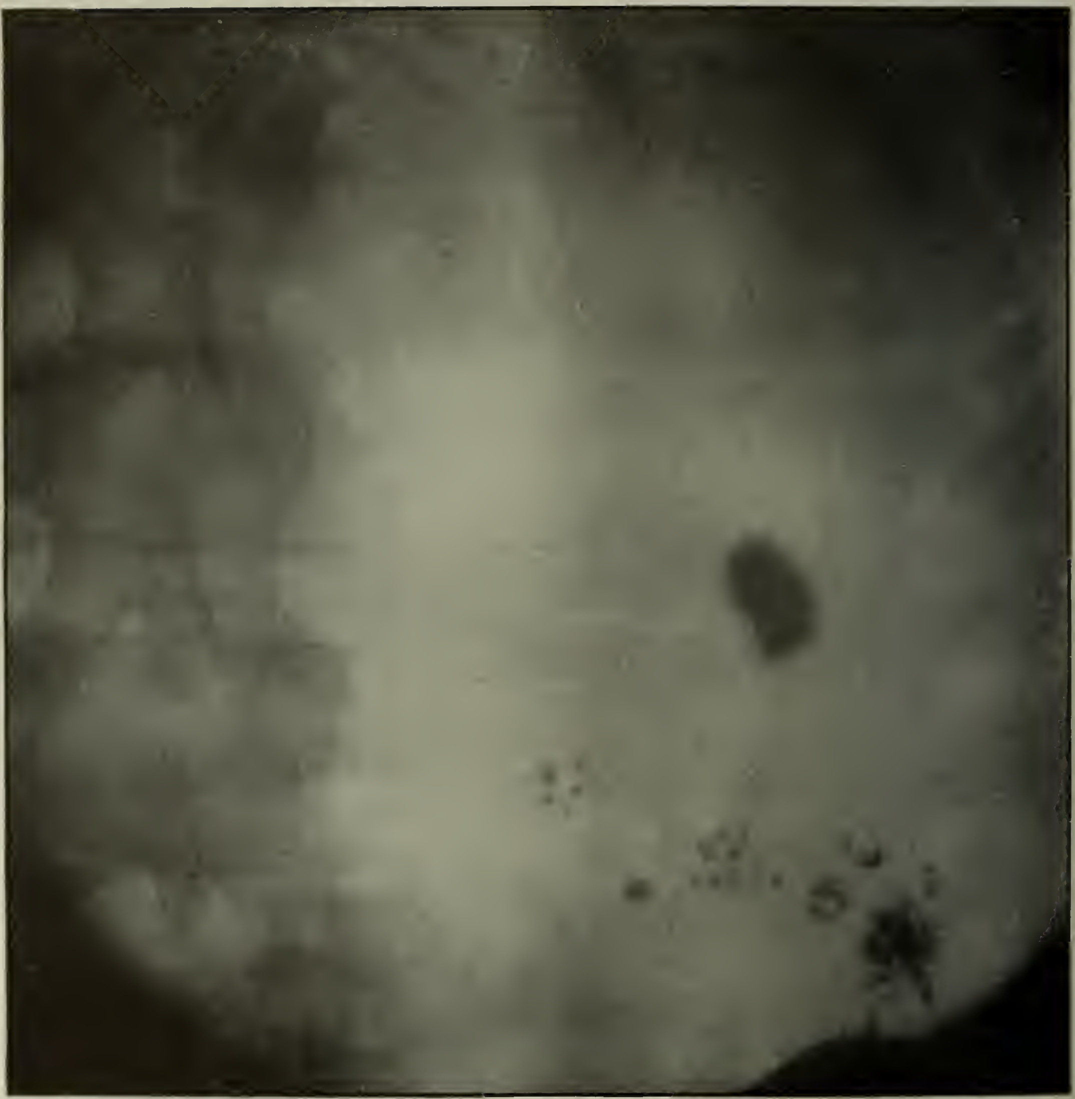
The nearly normal size of the shadow of the projectile shows it to be much nearer the posterior than the anterior chest wall. The blurred outline shows it to have moved with respiration. Such conditions locate its position within the thoracic cavity.

The emergency treatment is antiseptic dressing and rest.

The subsequent treatment depends upon pleural involvement or the extremely rare infection of the lung.

These cases are nearly all aseptic, and if the great vessels and nerves of the chest escape injury results are generally favorable.

Plate 46.



RIFLE—PLATE 46.

PELVIS.

Gunshot Wound of the Pelvis, with Lodgment of the Missile in the Abdomen.

The course of the bullet was from behind forward, striking the crest of the ilium, on which it was deflected, and spattering off some lead fragments. The slight penetration indicates a velocity of extremely long range and a striking energy lessened by ricochet.

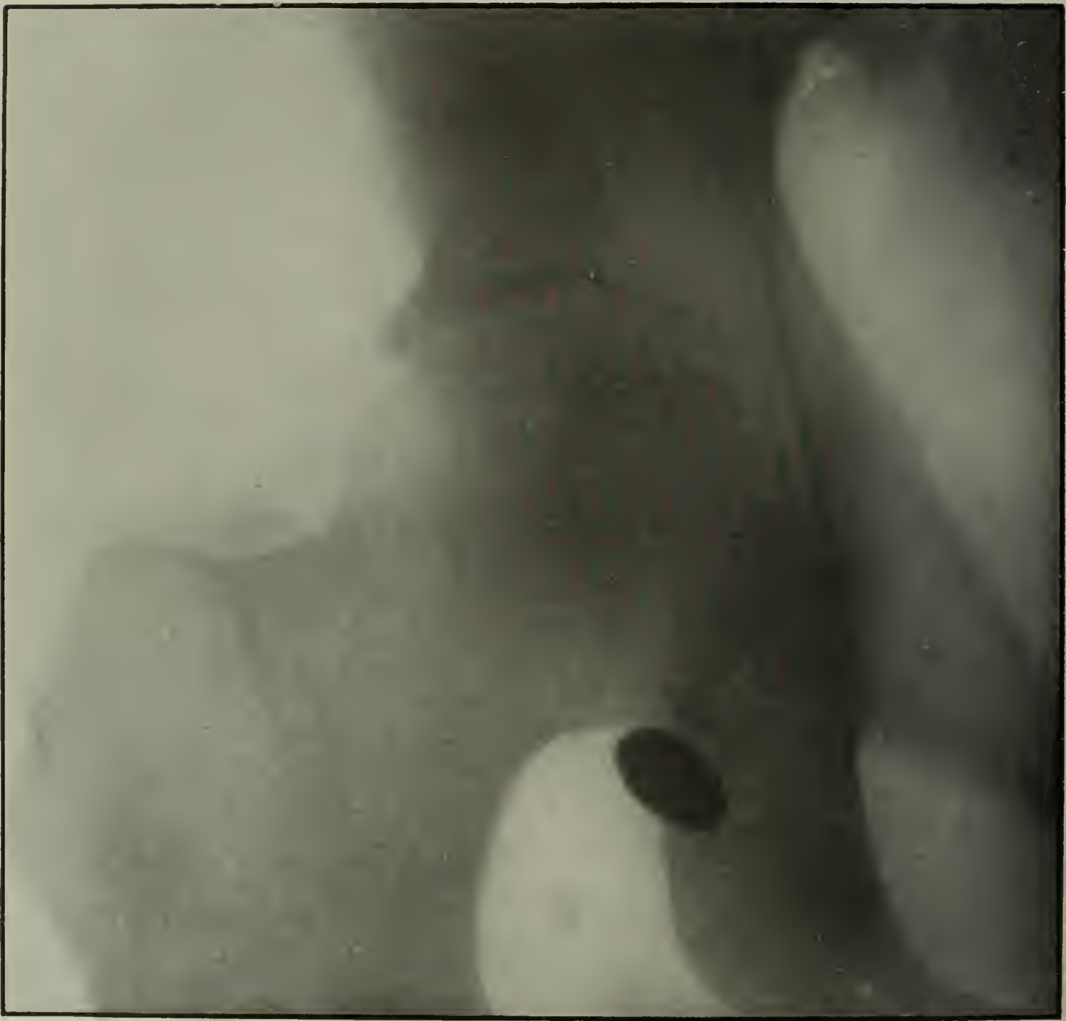
The irregular outline of the shadow of the projectile shows its deformity, and the blurred outline indicates intra-abdominal movement with respiration.

While the missile, as revealed by its shadow, is not a shrapnel ball, the distribution of lead particles is more suggestive of a shrapnel than of a rifle projectile, and the ballistic conditions are more characteristic of the former than of the latter.

There was no abdominal reaction; the invasion of the abdomen was revealed by the radiograph.

The treatment in such cases is noninterference unless subsequent developments furnish definite indications.

Plate 47.



RIFLE—PLATE 47.

LOWER EXTREMITY.

Gunshot Wound of the Gluteal Region, with Lodgment of the Bullet Near the Ischium.

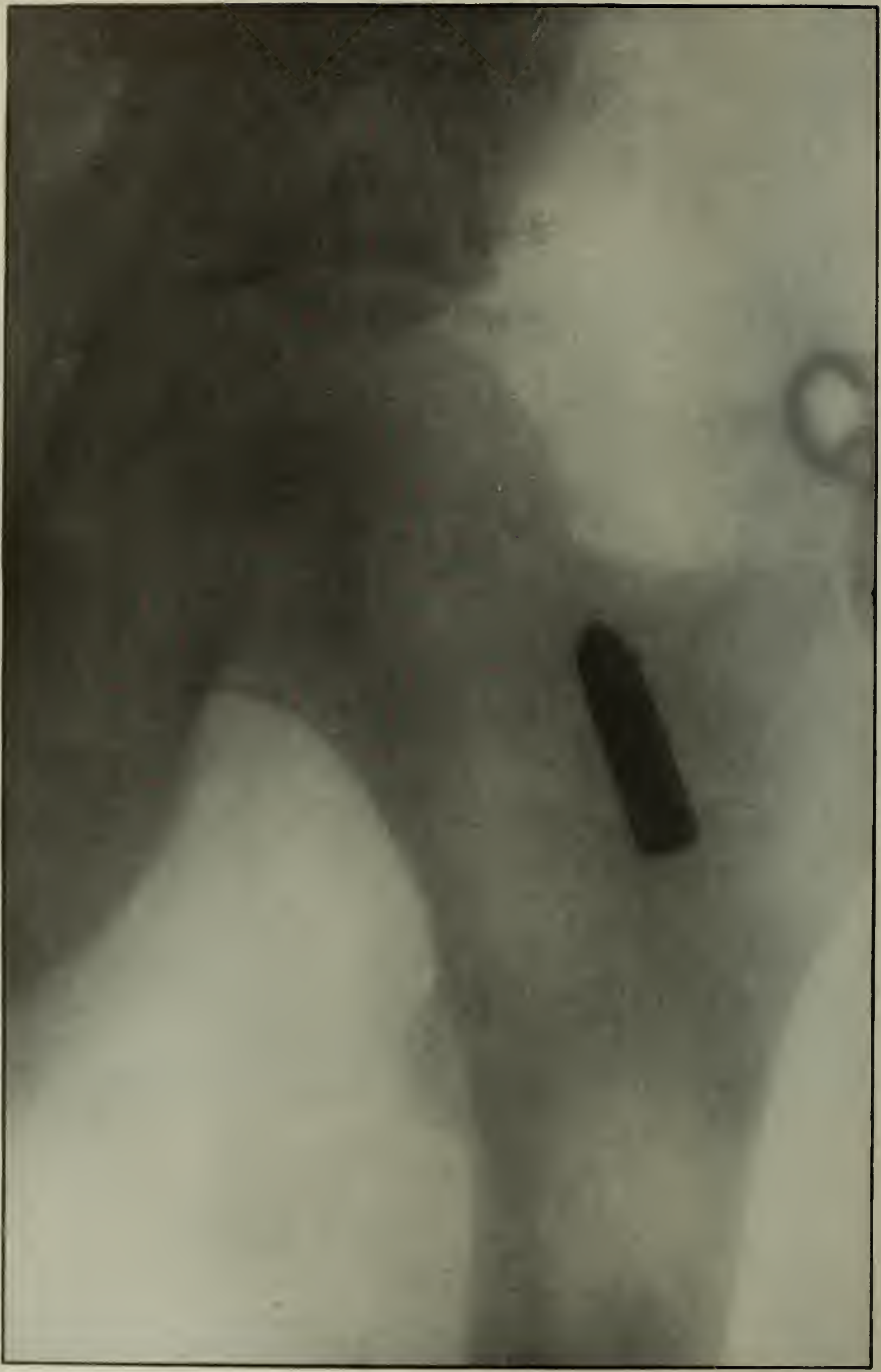
Wound of entrance, over gluteal prominence on a transverse line through the great trochanter.

Wound of exit, none.

There was no bone injury in this case. The bullet, to have lodged in the soft parts after relatively slight penetration, must have struck the body at extreme range when its energy was almost spent in flight, for its normal outline indicates that it was not retarded by ricochet. The long axis is almost perpendicular to the plate. As the posterior pelvis was next to the plate, the fairly dense shadow shows the projectile was not far from the plate and behind the ischium.

The treatment is conservative; infection in such cases is extremely rare; and only pain or impaired function after many months of convalescence justifies operation for removal of the missile.

Plate 48.



RIFLE—PLATE 48.

LOWER EXTREMITY.

Gunshot Wound of the Thigh, with Lodgment of the Bullet.

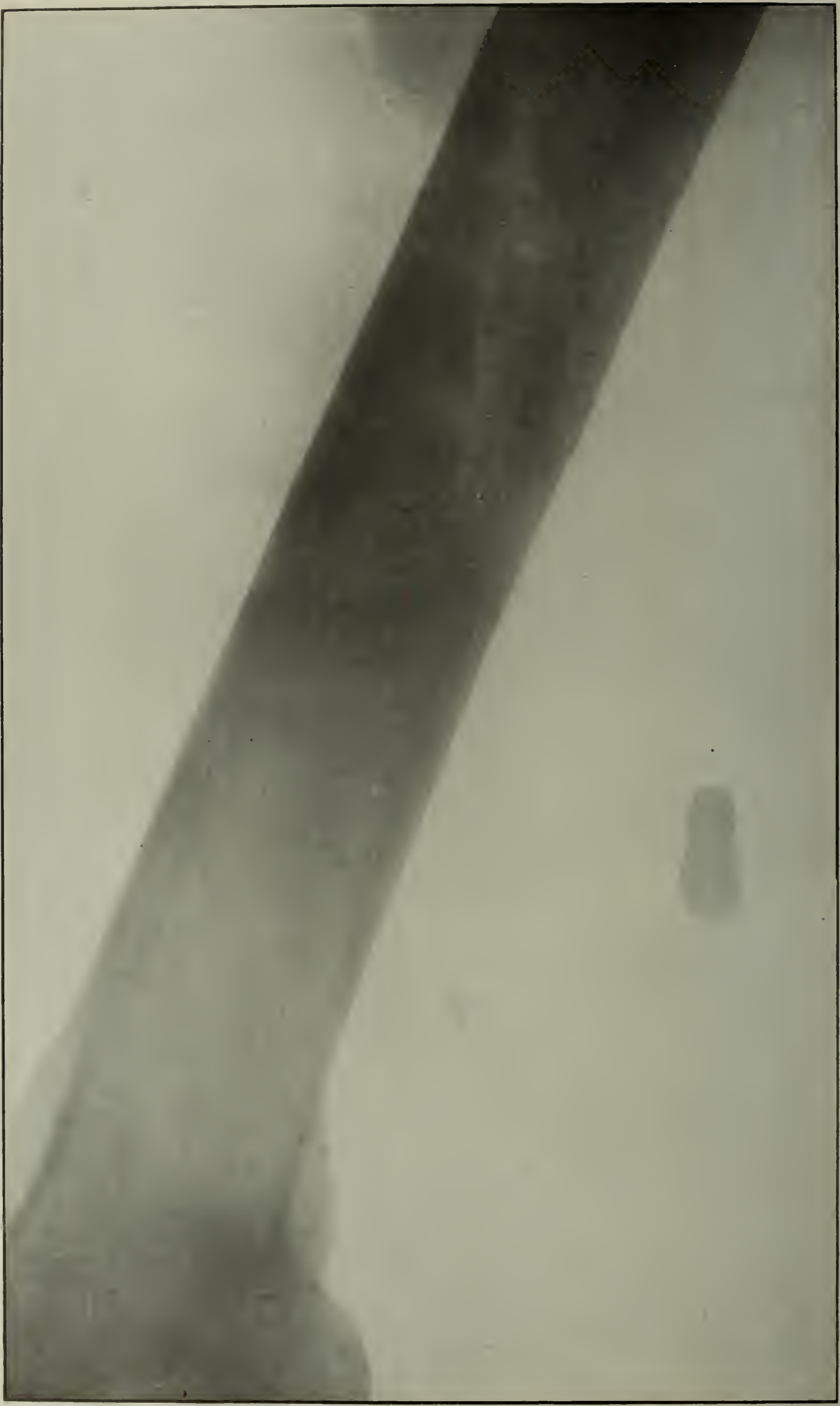
Wound of entrance, outer aspect of the thigh at the junction of the upper and middle thirds.

The slight penetration without bone injury and with slight deformity of the nose of the bullet indicates that the wound was caused by a ricochet shot at extreme range, after its energy was almost spent.

With the posterior aspect of the thigh next to the plate, the dense shadow and the nearly normal size of its outline indicate that the bullet was in the same relative position and that it lay posterior to the neck of the femur.

As such wounds are rarely infected, the treatment is conservative, and a search for the missile is only justified by serious infection, pain, or impaired function.

Plate 49.



RIFLE—PLATE 49.

LOWER EXTREMITY.

Gunshot Wound of the Right Thigh, with Lodgment of the Bullet Behind the Femur.

There is no injury of the bone in this case, as the bullet lodged in the muscles posterior to the lower third of the femur without striking the bone. The lighter circular area of the larger end of the shadow of the projectile shows that its base is farther from the plate than its nose, which was probably flattened and bent by the ricochet which reduced its velocity so as to give it but slight power of penetration.

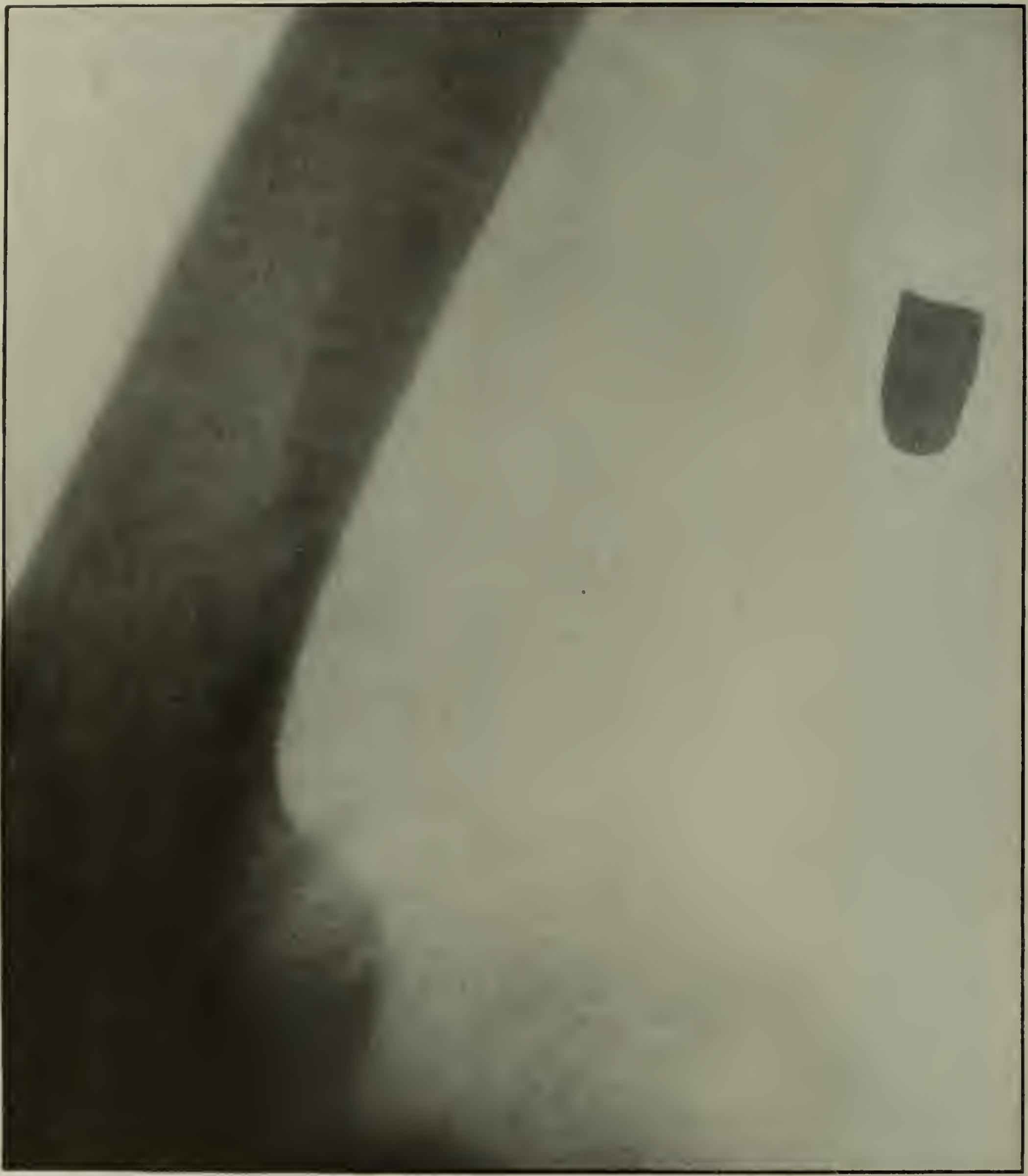
It is not easy to determine from inspection of the plate which side of the leg lay next to the plate.

With a history of the wound of the right thigh and with the outside of the leg next to the plate, the projectile must have lain near the plate on the outside behind the lower end of the femur, midway between the skin and bone.

The markings seen on the bone are not concerned with the wound, as the same effect in the plate is seen in the areas beside the bone.

The treatment is conservative; infection is rare.

Plate 50.



RIFLE—PLATE 50.

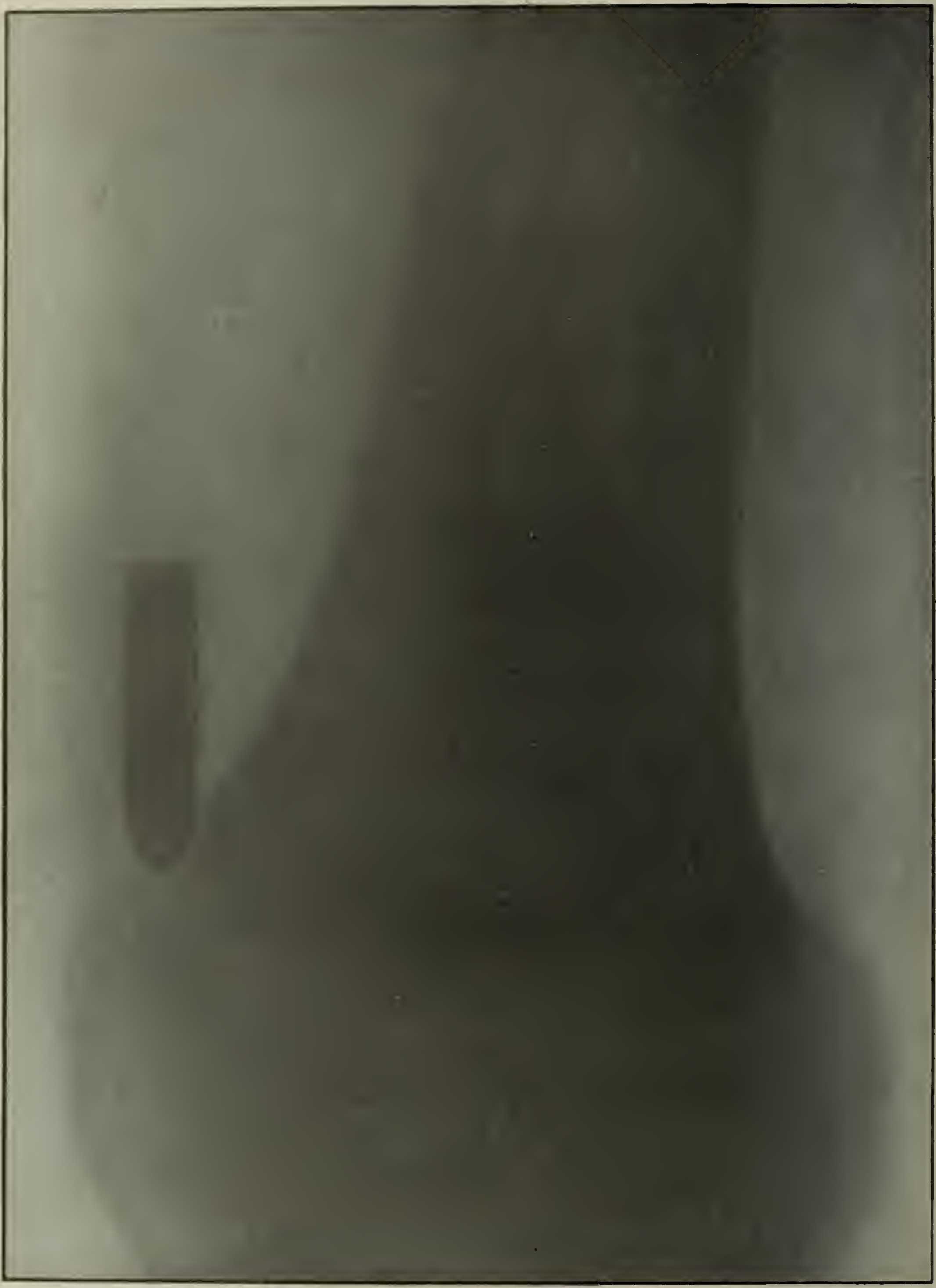
LOWER EXTREMITY.

Gunshot Wound of the Right Thigh, with Lodgment of the Bullet Behind the Femur.

There is no injury to the bone. The large diameter, shortened length, and slight density of the shadow show the bullet to be some distance from and inclining toward the plate and lodged in the muscles behind the femur, nearer the side away from the photographic plate. It is difficult to identify the right or left thigh from the radiograph, but with the history of the wound in the right thigh and the outside of the leg next to the plate the ball would lie nearer the inside than the outside of the thigh, nearer the surface behind the femur. As the shadow shows irregular outline and the location of the bullet low velocity, the wound was caused by a ricochet shot at very long range.

The treatment is expectant and the course naturally favorable.

Plate 51.



Rifle—Plate 51.

LOWER EXTREMITY.

Gunshot Wound of the Thigh, with Lodgment of the Missile.

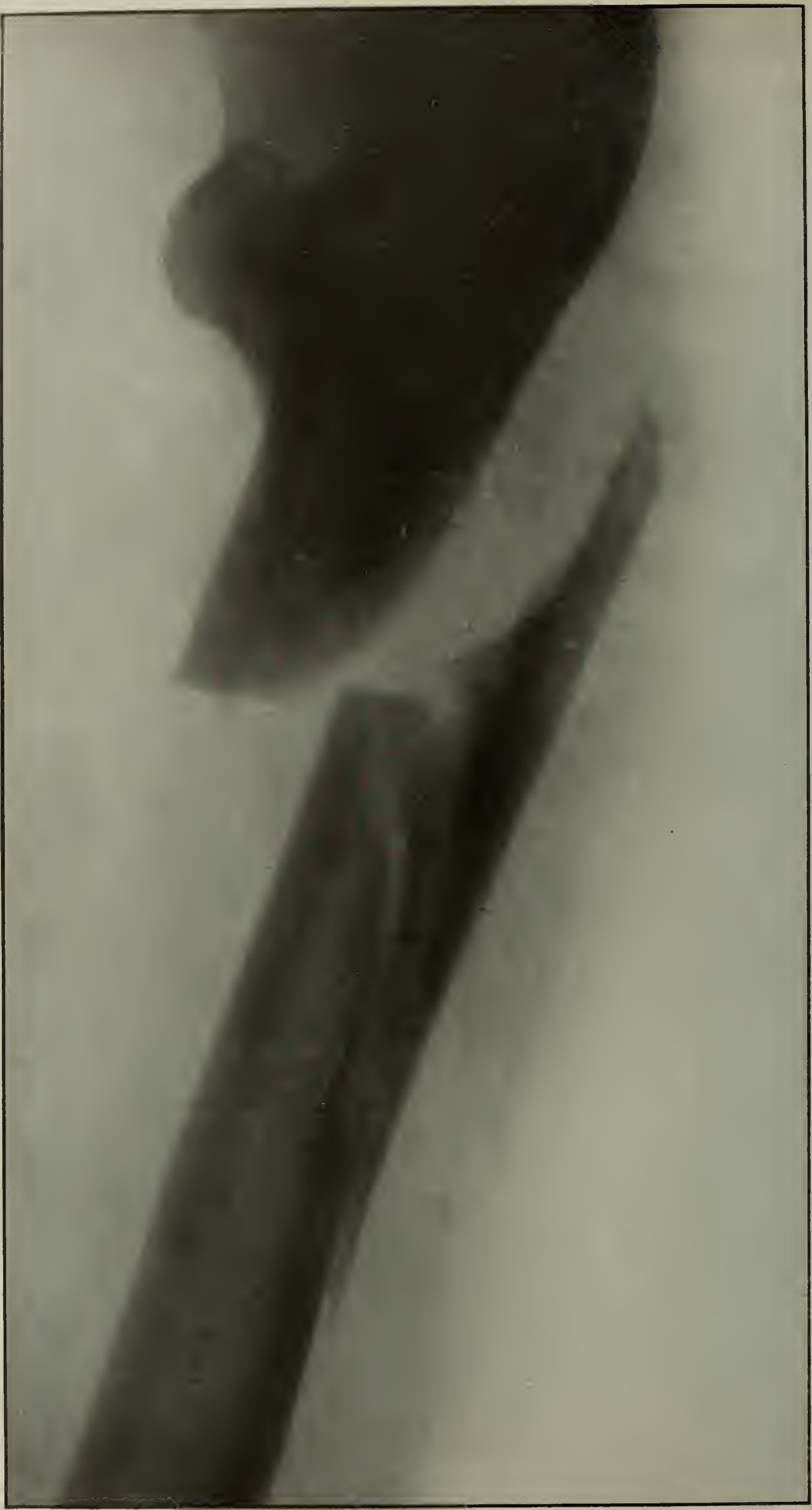
As there is no injury to the bone, the bullet is not deformed. Its penetrating power was not great enough to carry it through the tissue so it must have struck the leg at extreme range when its energy was almost spent.

The actual length of the bullet is 1.25 inches; the length of the shadow is about 1.50 inches.

The increased length and the relatively slight density of the shadow indicate the bullet to be some distance from the plate. The case history places the wound in the right thigh, and the posterior surface of the leg lay next to the photographic plate. As the density of the shadow is not greater than the thickest portion of the bone, the bullet probably lies in front of the border of the outer tuberosity of the femur.

Although the surgeon's diagnosis had to be made from the only available plate, there is something of a speculative element in these deductions, because if the reaction in the knee joint prevented the patient from extending the leg the increased length of the bullet shadow could be accounted for by this position, which would permit the bullet to lie behind the bone and yet far enough from the plate to account for the shadow enlargement. The nose of the bullet is at the epiphyseal line, which is shown in the femur.

Plate 52.



RIFLE—PLATE 52.

LOWER EXTREMITY.

Gunshot Fracture of the Upper Shaft of the Femur.

The course of the bullet was anteroposterior and pierced the axis of the shaft of the femur with three radiating lines of fracture, resulting from the perforating action of the bullet striking the bone at long range and with greatly reduced energy.

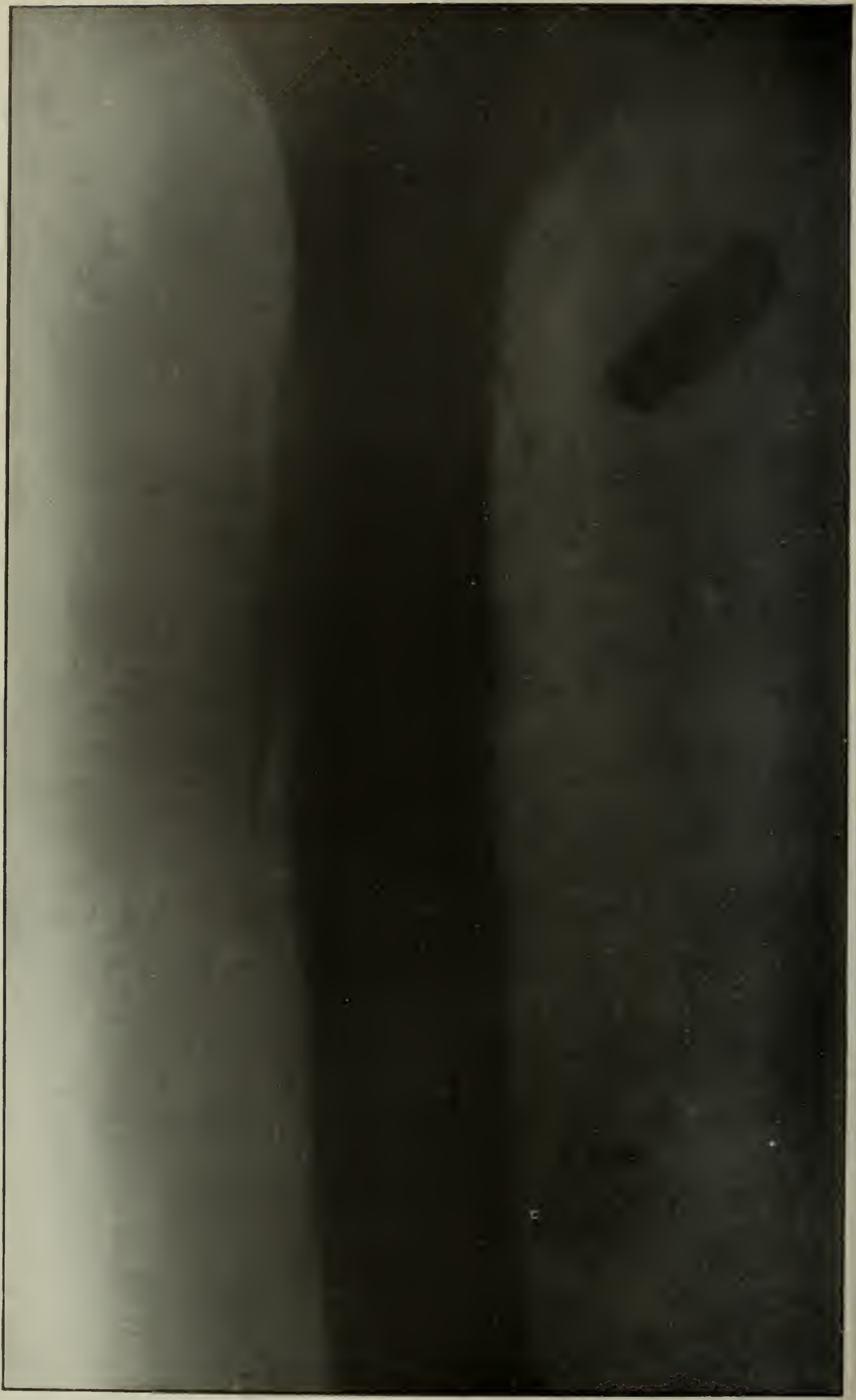
This plate shows the lateral separation of large fragments, which is typical of gunshot wounds of long range.

Such wounds are usually not infected.

Emergency treatment is antiseptic dressing and coaptation with extension and temporary splint, so that it may support the bone for transportation and may be easily removable at place of continued treatment.

In these cases with lateral separation of fragments, it is imperative to supplement extension with pressure in a line perpendicular to the long axis of the femur.

Plate 53.



RIFLE—PLATE 53.

UPPER EXTREMITY.

Gunshot Fracture of the Shaft of the Femur with Lodgment of the Bullet.

The course of the bullet was antero-posterior and diagonally inward from the antero-external border of upper third of the thigh. A thin longitudinal fragment was split off without transverse fracture.

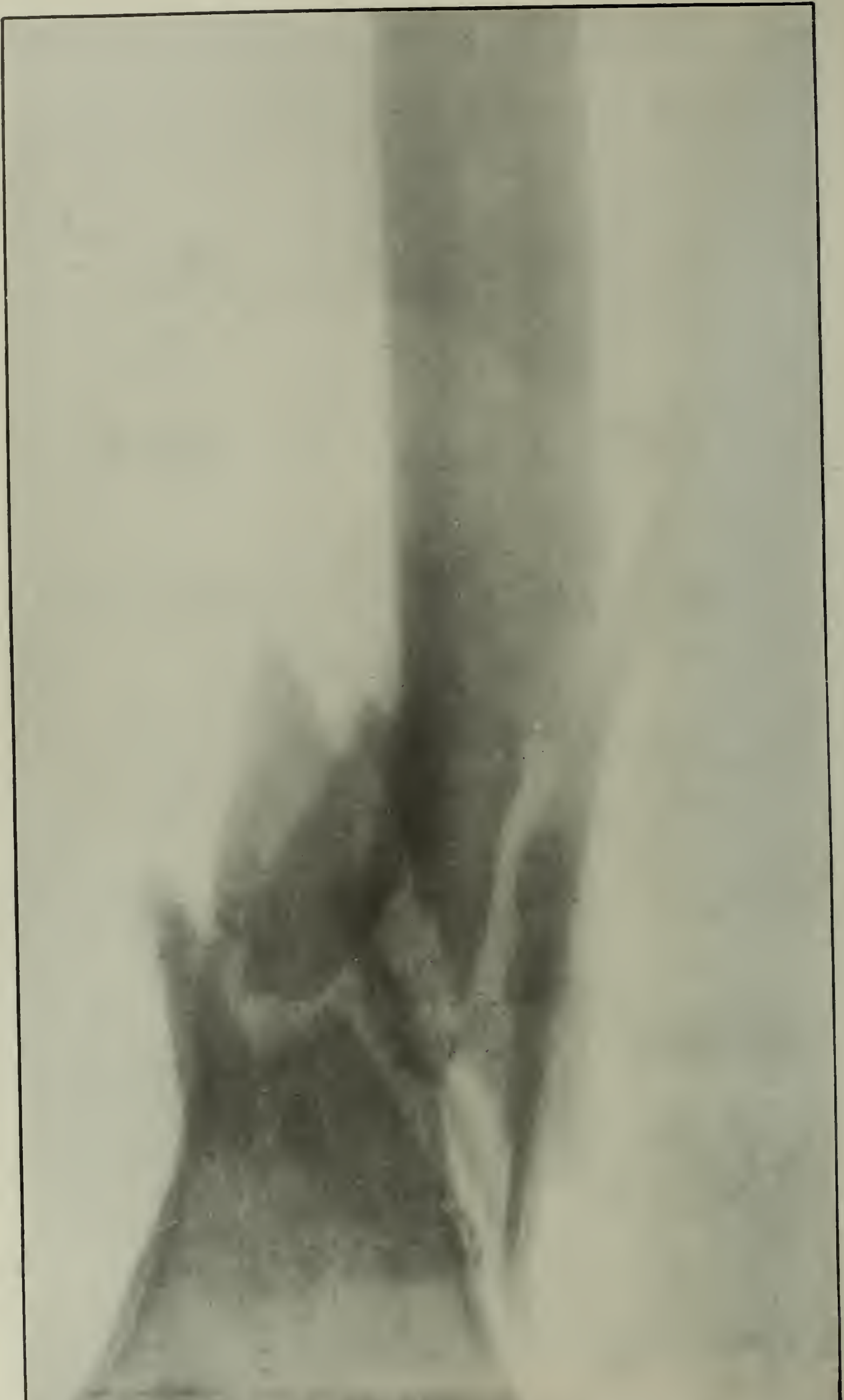
The missile struck the thigh after its energy had been greatly reduced by ricocheting as a result of striking a resisting object which flattened its nose and "set up" its body, as shown by the wavy outlines of the shadows.

The dense and normal-size shadow shows the bullet to be near the plate and probably in the muscles superficially behind and below the lesser trochanter.

As the prominent outline of the lesser trochanter shows that the leg was in external rotation when the negative was made, it is evident that, with the rotation back to the anatomical position, the projection of the shadow of the bullet would fall close to or in line with the shaft of the femur; the position of the bullet is behind the femur.

The treatment is conservative, with no trouble to be expected from infection.

Plate 54.



RIFLE—PLATE 54.

LOWER EXTREMITY.

Gunshot Fracture of the Lower End of the Shaft of the Femur.

The course of the bullet was anteroposterior through the axis of the femur. Several large fragments which were not displaced were separated by the force of impact. The separation of the fragments and the overriding of the ends of the proximal and distal large fragments were due to bearing bodily weight or to muscular contraction.

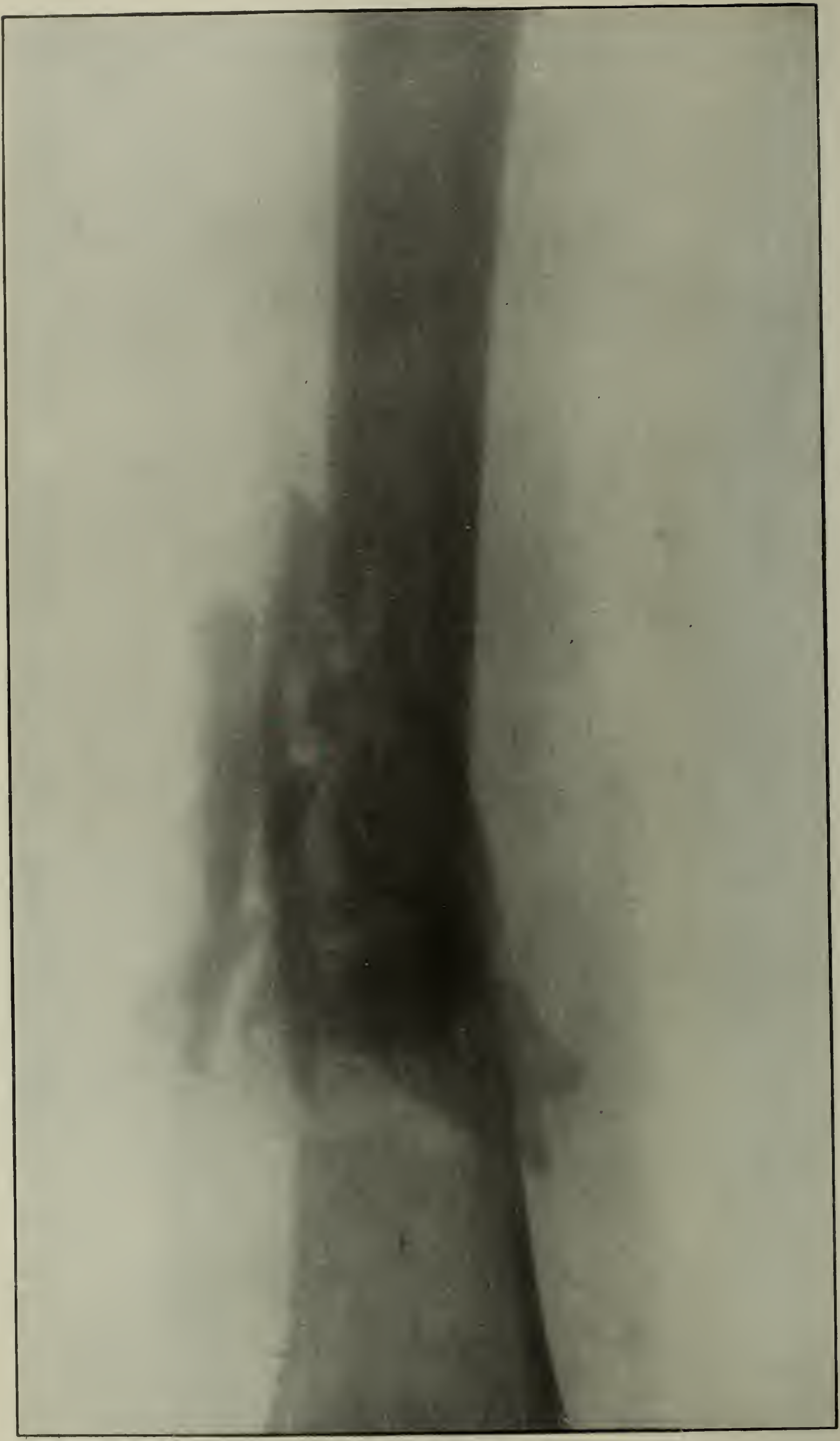
The projectile causing the wound was moving with the velocity of mid range. The wound of exit was not lacerated.

The emergency treatment is antiseptic dressing and temporary splint immobilization. Permanent dressing, with extension and lateral compression, is the rule.

Infection in such cases is frequent owing to lack of facilities for proper dressing on the field.

Results in saving life and limb are generally good.

Plate 55.



Rifle—Plate 55.

LOWER EXTREMITY.

Gunshot Fracture of the Lower Third of the Shaft of the Femur.

The course of the bullet was diagonally anteroposterior, with a velocity near mid range, without causing much displacement of fragments.

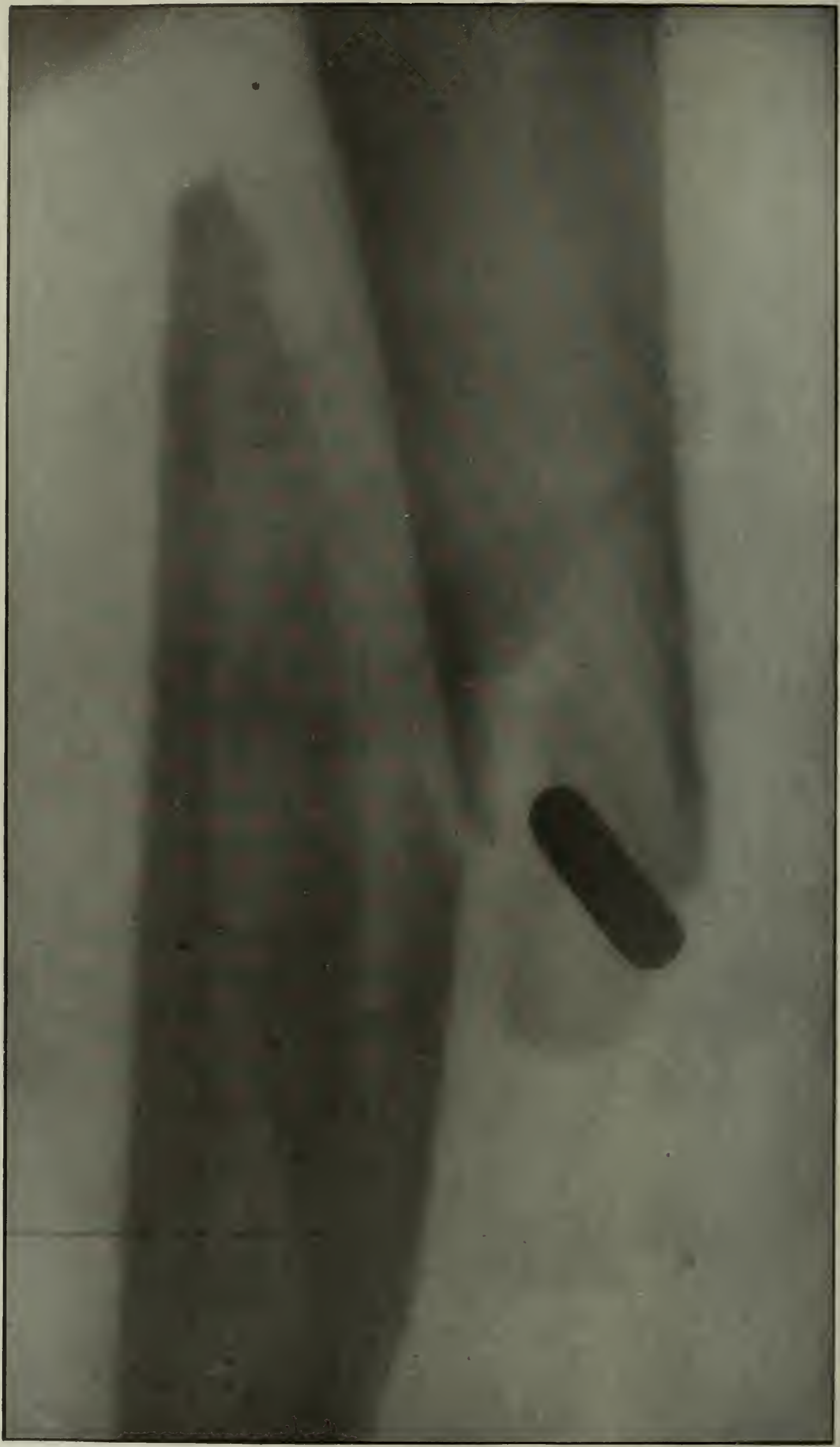
The wound of entrance and exit would be almost the same in appearance.

Treatment and results would be similar to case shown on plate 54. Many of these wounds are infected, due, no doubt, to the difficulties of arranging a clean first-aid dressing and effecting satisfactory immobilization during the first stage of transportation.

Infection from clothing carried into the wound is rare, as the fairly high velocity of the bullet causes a spreading of the fibers without division or punched-out section before the bullet.

As a rule the infected cases of this class recovered without loss of limb. Amputation was very rare.

Plate 56.



RIFLE—PLATE 56.

LOWER EXTREMITY.

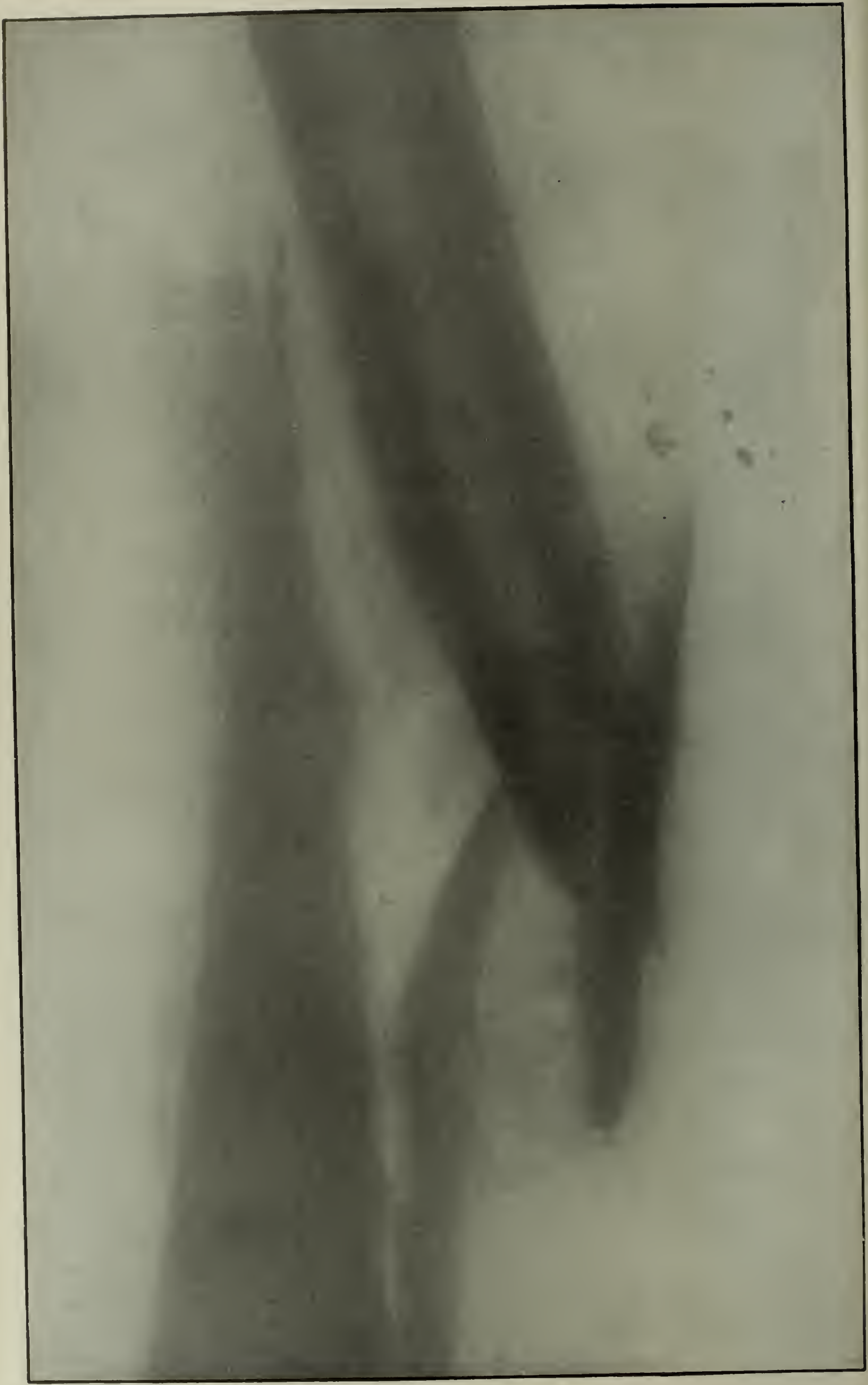
Gunshot Fracture Below the Middle of the Femur, with Lodgment of the Bullet Near the Fracture.

The course of the projectile was transverse. The long splitting fracture, with few large fragments and the lodged undeformed missile, indicate that the injury to the bone was caused by the missile striking the bone with large cross section or at an inclined angle so that all of the remaining energy of the projectile at long range was absorbed by the bone.

Had the point of the ball struck the bone with the same energy, it would have produced smaller fragments and might then have passed beyond the bone. The normal size of the diameter, slightly shortened length, greater density of the point of the shadow, shows the bullet to lie behind the bone with its nose pointing slightly backward. The actual length of the bullet is 1.25 inches; the length of the shadow is 1 inch.

Treatment and results would be about the same as in plates 49 and 50.

Plate 57.



RIFLE—PLATE 57.

LOWER EXTREMITY.

Gunshot Fracture About the Middle of the Femur, with Lodgment of the Fragments of a Deformed Bullet.

The course of the missile was transverse. All of the remaining energy of the retarded velocity of the short range of a ricochet shot was stopped by the bone with the result of a long splitting fracture, and the lodgment of one large and a few small fragments of the missile.

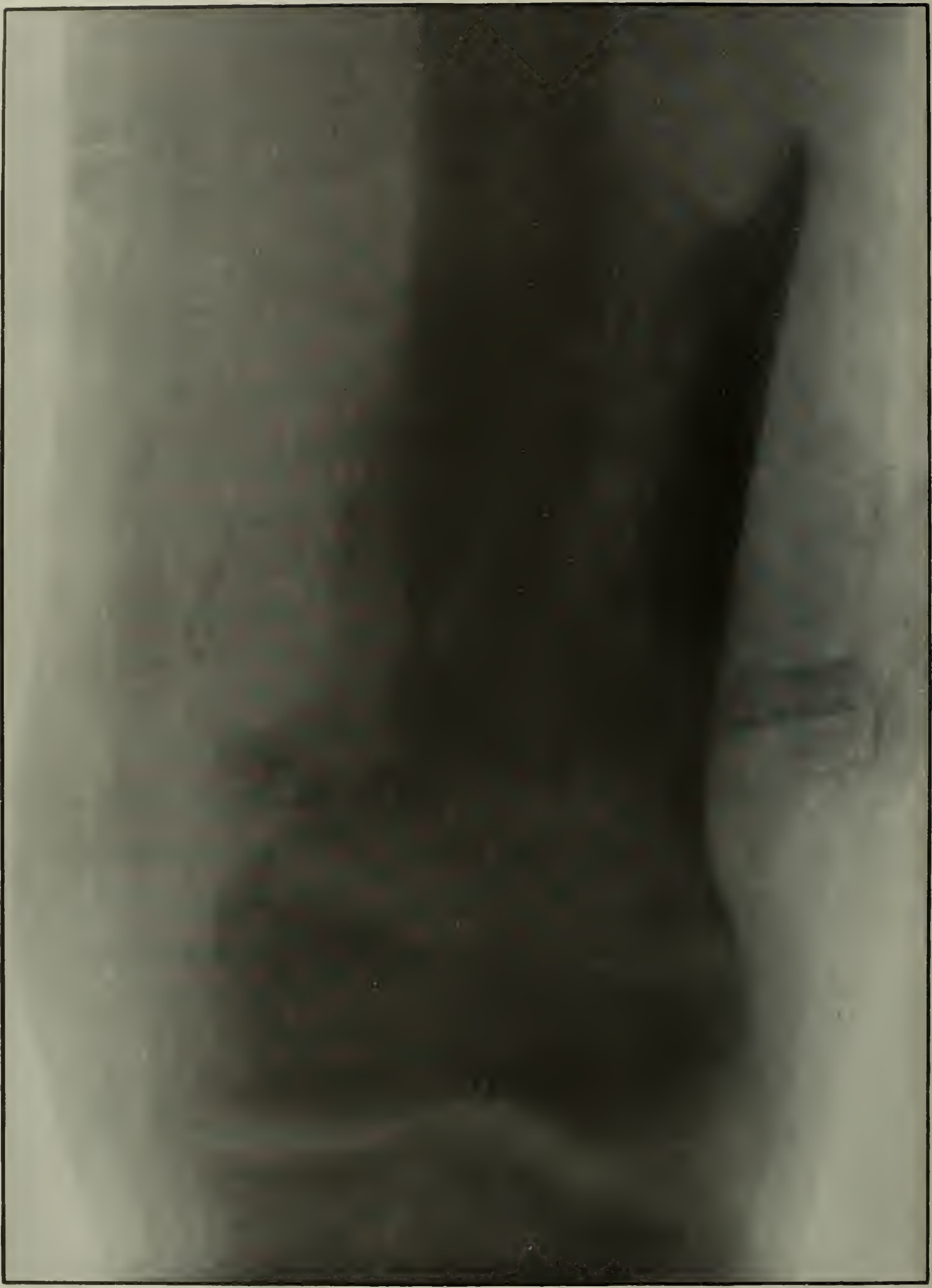
The small notched metal fragment lying to the right of the upper bone fragment is a small bent piece of the jacket, detached from the greatly deformed lead core, which can be faintly seen lying behind the lower end of the left side of the upper bone fragment.

The treatment is extension with lateral compression, although this case, showing by callus formation advancing convalescence, reveals very bad position.

Results as to life and limb are favorable in such cases, but some deformity is to be expected.

It should be noted that this is a case from Gulhané Hospital, the best military hospital in Constantinople, where the surgical service, under Prof. Wieting Pasha, was skillfully conducted.

Plate 58.



RIFLE—PLATE 58.

LOWER EXTREMITY.

Gunshot Fracture of the Lower End of the Femur.

The course of the bullet was anteroposterior.

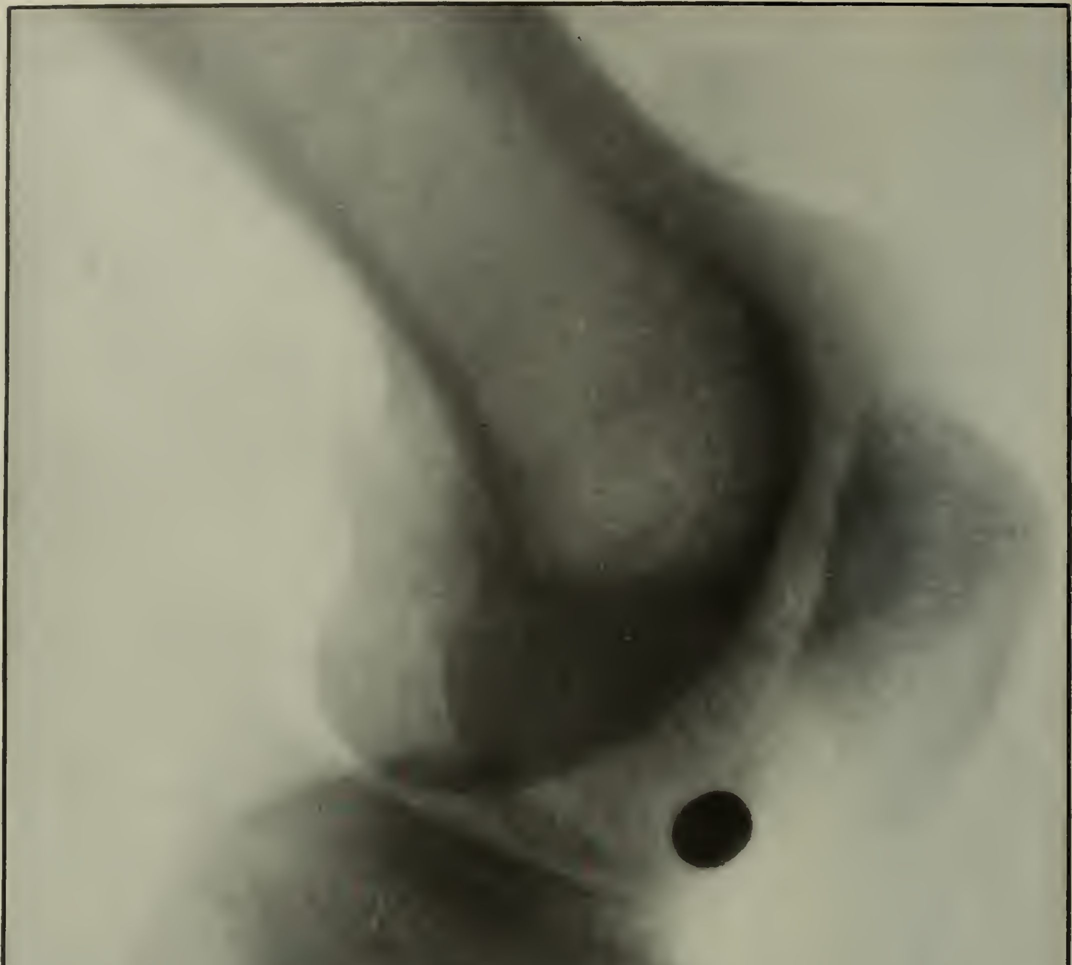
The long, oblique, splitting fracture without separate fragments indicates the long range of the missile in low velocity.

The wound was infected as is indicated by the drainage tubes in place. The well-advanced callus formation indicates established convalescence.

Results are favorable for recovery with only fair position and some shortening.

It may be observed that this is also a case from Gulhané Hospital.

Plate 59.



RIFLE—PLATE 59.

LOWER EXTREMITY.

Gunshot Wound of the Left Knee-Joint, with Lodgment of the Missile in the Joint.

The course of the bullet was transverse, entering the capsule posterior to the patella without injury to the bone.

As its shadow projection is almost circular, the bullet must be standing almost on its end pointing toward the plate with its long axis almost parallel to the line of projection.

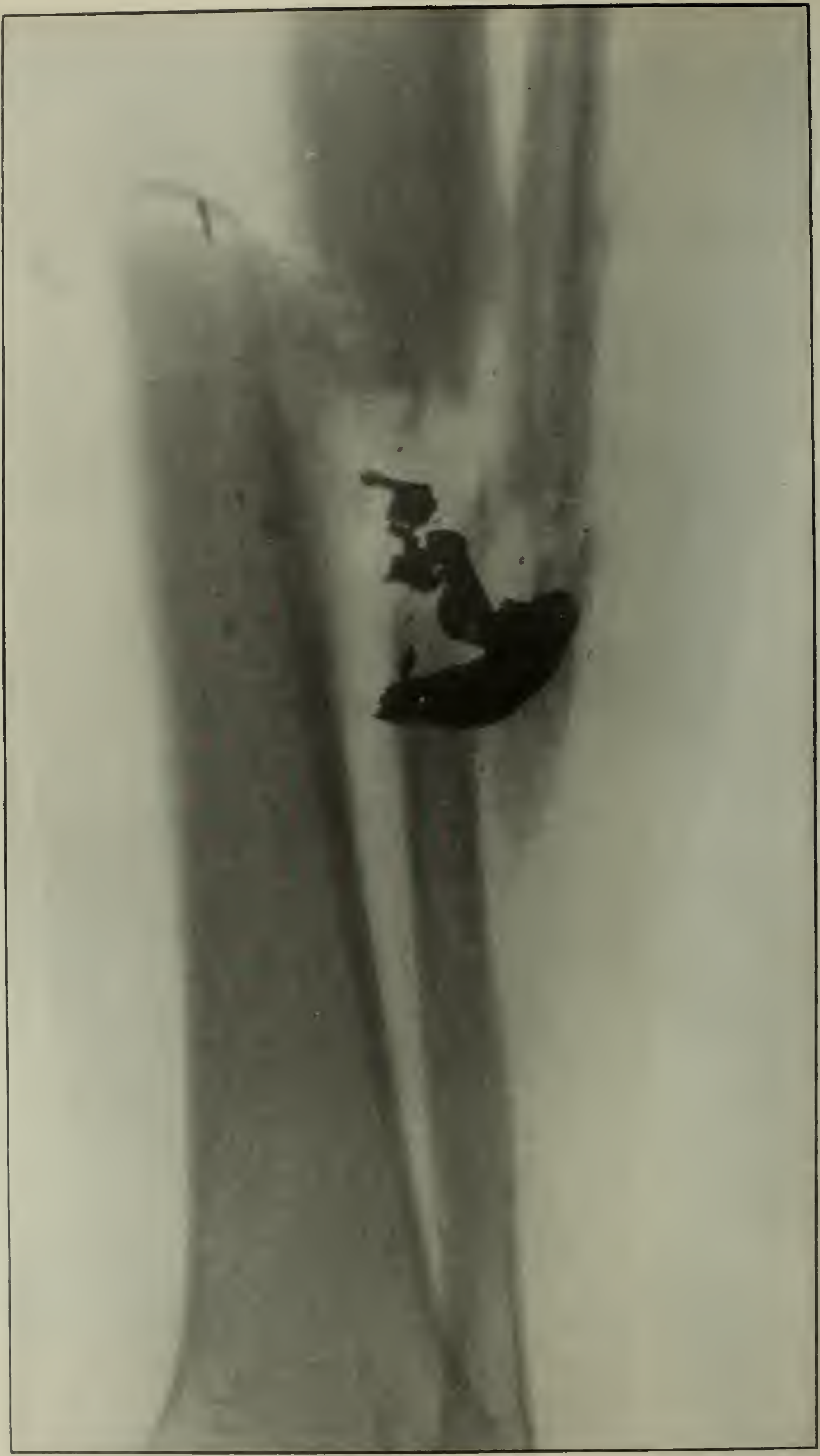
As the fibular side of the leg lay next to the plate and as the only slightly enlarged shadow of the bullet indicates it to be near the plate, its position is in the joint near the fibular side.

As the bullet is undeformed and its penetrating power very slight, its velocity was that of extreme range.

The emergency treatment, is, of course, a simple antiseptic dressing with the leg held in the most comfortable position by muscular action.

The subsequent treatment is removal of the bullet when proper surgical conditions obtain.

Plate 60.



RIFLE—PLATE 60.

LOWER EXTREMITY.

Gunshot Fracture of the Tibia and Fibula, with Lodgment of the Missile.

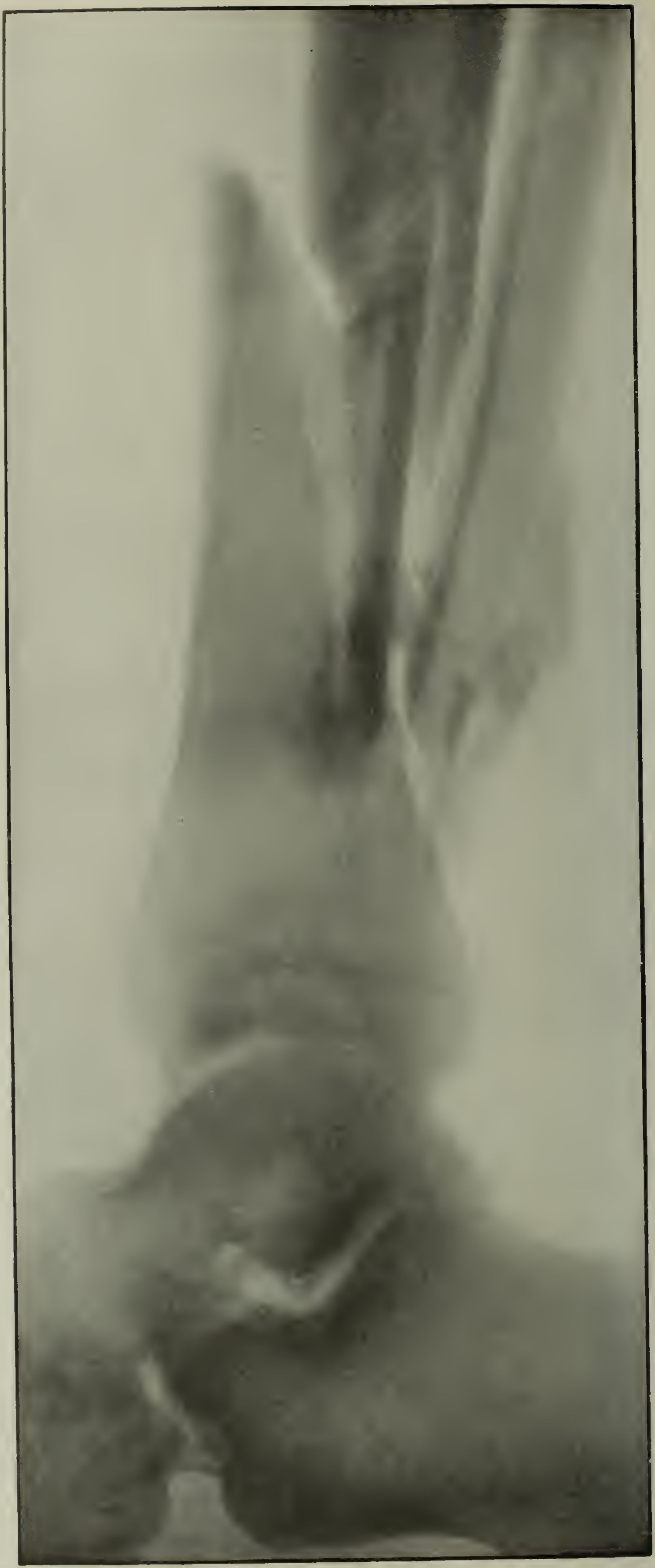
The course of the bullet was diagonal from within outward and backward about the middle of the leg, with the impact tangential on the tibia and direct on the fibula. The bullet lies just behind the tibia.

It is apparent that the bullet has been greatly deformed and that its jacket has been badly torn from the core. The force of impact on the object from which it ricocheted must have been contributed by the velocity of short range, which reduced the striking energy so greatly that the bullet was lodged by the resistance of the tibia and fibula.

The wound was not infected, and callus formation shows that repair has begun.

The treatment in such cases, without infection, is noninterference. The lodgment of the missile need not prejudicate the prognosis, and certainly the additional damage in the search for the bullet is not warranted, except under special indications.

Plate 61.



RIFLE—PLATE 61.

LOWER EXTREMITY.

Gunshot Fracture of the Lower Ends of the Tibia and Fibula.

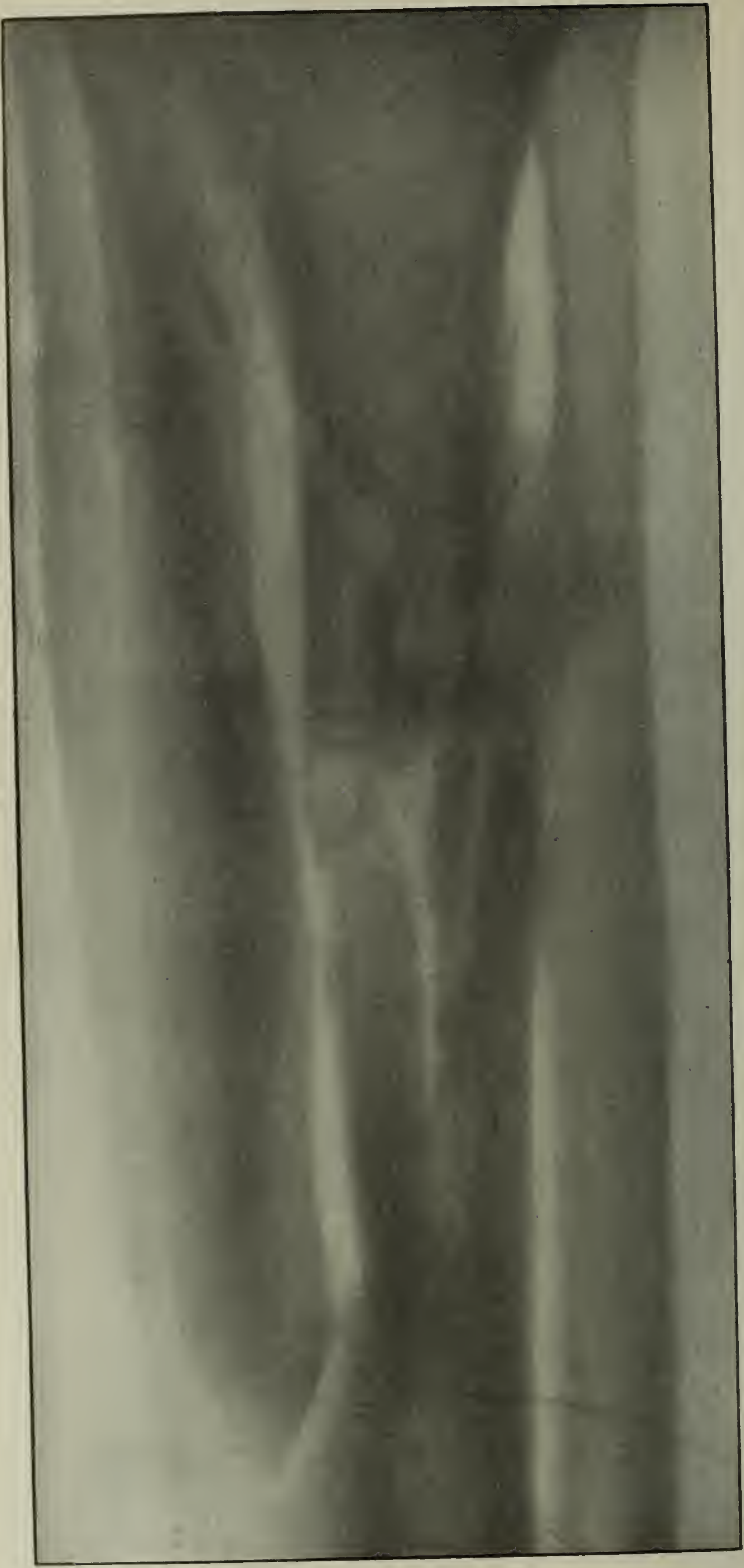
The course of the bullet was transverse, with the velocity of mid-range.

The fragmentation of the fibula, lying close to the skin, would produce considerable laceration in the wound of exit.

The treatment is conservative. Infection would depend almost entirely upon the integrity of the first dressings and immobilization.

Results should be favorable, with care in subsequent treatment.

Plate 62.



Rifle—Plate 62.

LOWER EXTREMITY.

Gunshot Fracture of the Upper Third of the Tibia, with Large Longitudinal Fragment.

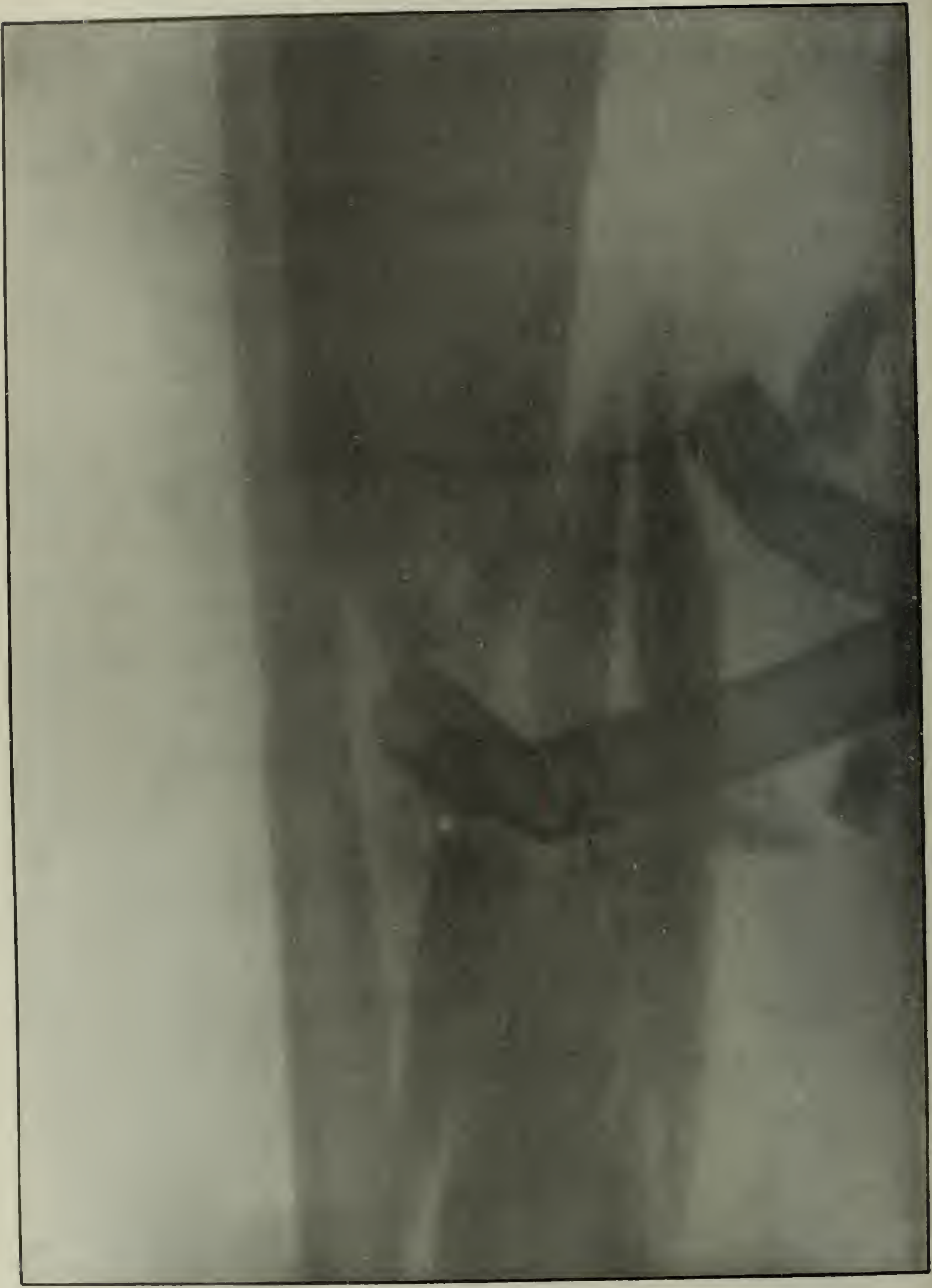
The course of the bullet was anteroposterior and slightly diagonal from without inward through the shaft of the tibia.

The injury was due to the energy of impact of a bullet, in the high velocity of short range, striking the axis of the diaphysis, in which the greater part of its energy was expended in pushing away a wall of the canal.

Convalescence is well established without infection, as shown by callus formation.

The treatment in such cases is invariably conservative, with the removal of such fragments as may be detached by suppuration and sequestration.

Plate 63.



RIFLE—PLATE 63.

LOWER EXTREMITY.

Gunshot Wound of the Middle of the Tibia, with Few Large Fragments.

The course of the bullet was transverse from without inward.

The direct impact of the bullet, in high velocity of short range, has produced the typical "X" fracture due to the radiating lines of force.

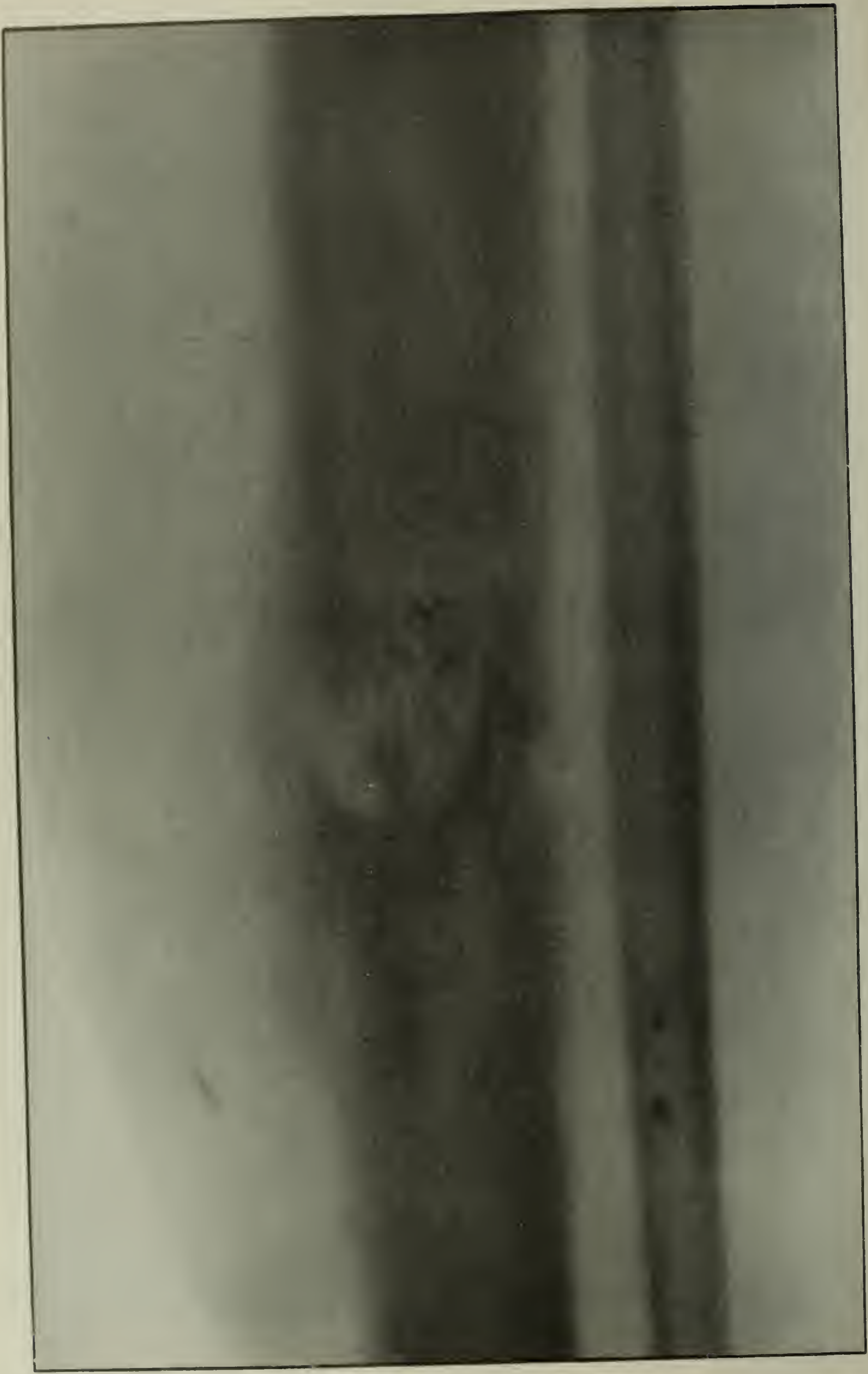
The wound was infected, as is shown by the drainage tubes in the wound.

The emergency treatment in such cases is simple antiseptic dressing and temporary splint immobilization.

The subsequent treatment is the management of the infection.

The results in such cases are favorable.

Plate 64.



Rifle—Plate 64.

LOWER EXTREMITY.

Gunshot Fracture of the Tibia.

The course of the bullet was diagonal, from without inward and from before backward through the middle of the tibia. Small particles of metal have lodged at the site of the fracture—a condition which never occurs in a rifle wound with the jacket of the bullet intact, while it is the invariable accompaniment of a shrapnel wound of a bone.

It is inferred that the jacket of the bullet in this case was damaged by ricochet, or that some metal particles from the object against which the bullet ricocheted were carried into the wound, as some other small pieces of metal are seen in areas distant from the seat of fracture.

As the fragments are small and not displaced, the velocity of the missile, at least that of mid-range, was almost sufficient to perforate the bone without fracture.

Plate 65.

Rifle—Plate 65.

LOWER EXTREMITY.

Gunshot Fracture of the Tibia.

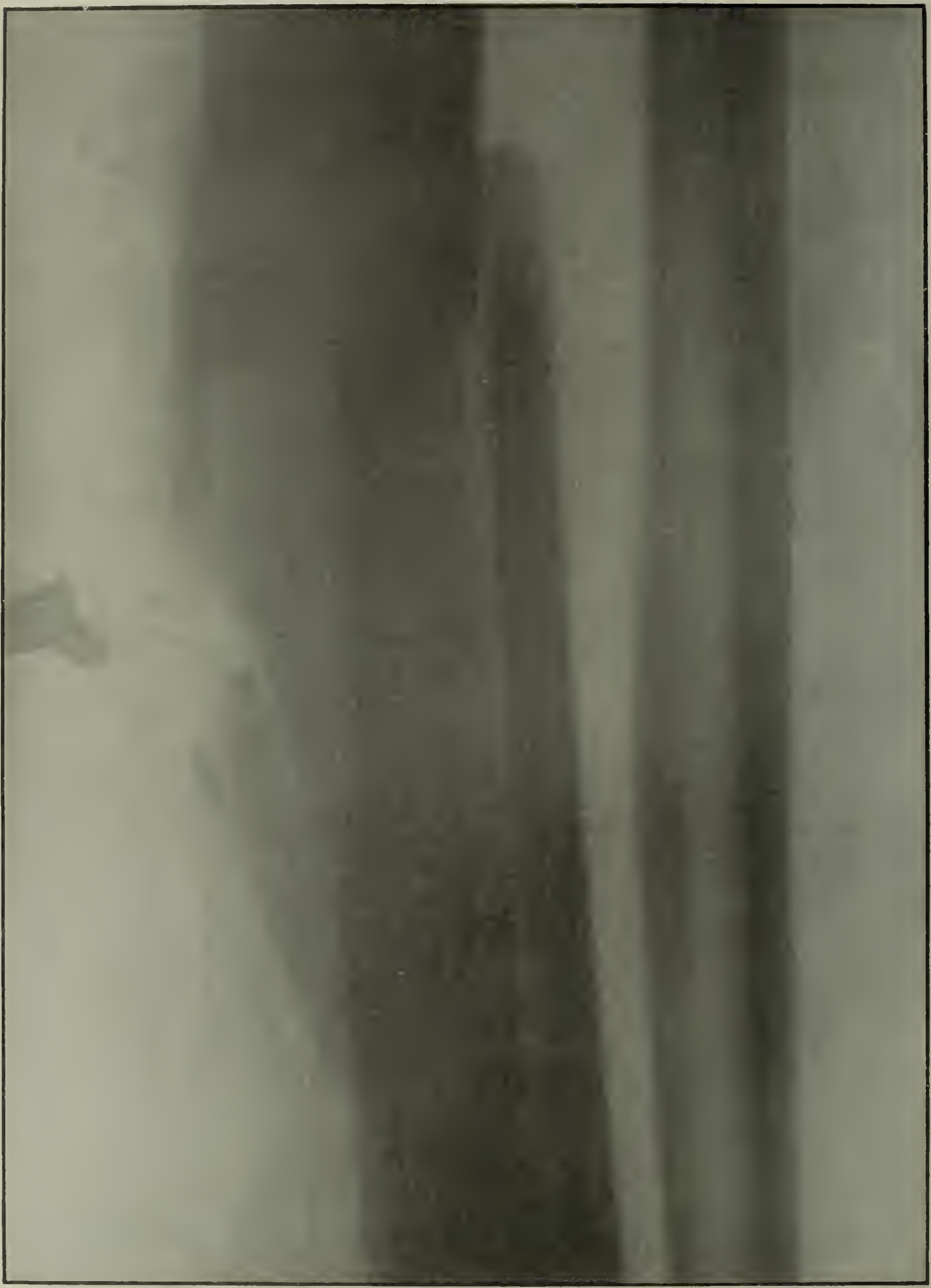
The course of the bullet was transverse, from within outward, striking the bone near the outer border with the velocity of mid or long range, producing long fissures without separation of fragments.

The safety pin, of course, lies in the dressings and on the side away from the plate, as shown by its somewhat indefinite outline and increased length.

The wounds of entrance and exit are practically the same.

The treatment in such cases is that of a simple fracture, except for the management of an occasional infection, and the results are favorable.

Plate 66.



RIFLE—PLATE 66.

LOWER EXTREMITY.

Gunshot Fracture of the Middle of the Tibia, with Lodgment of the Missile.

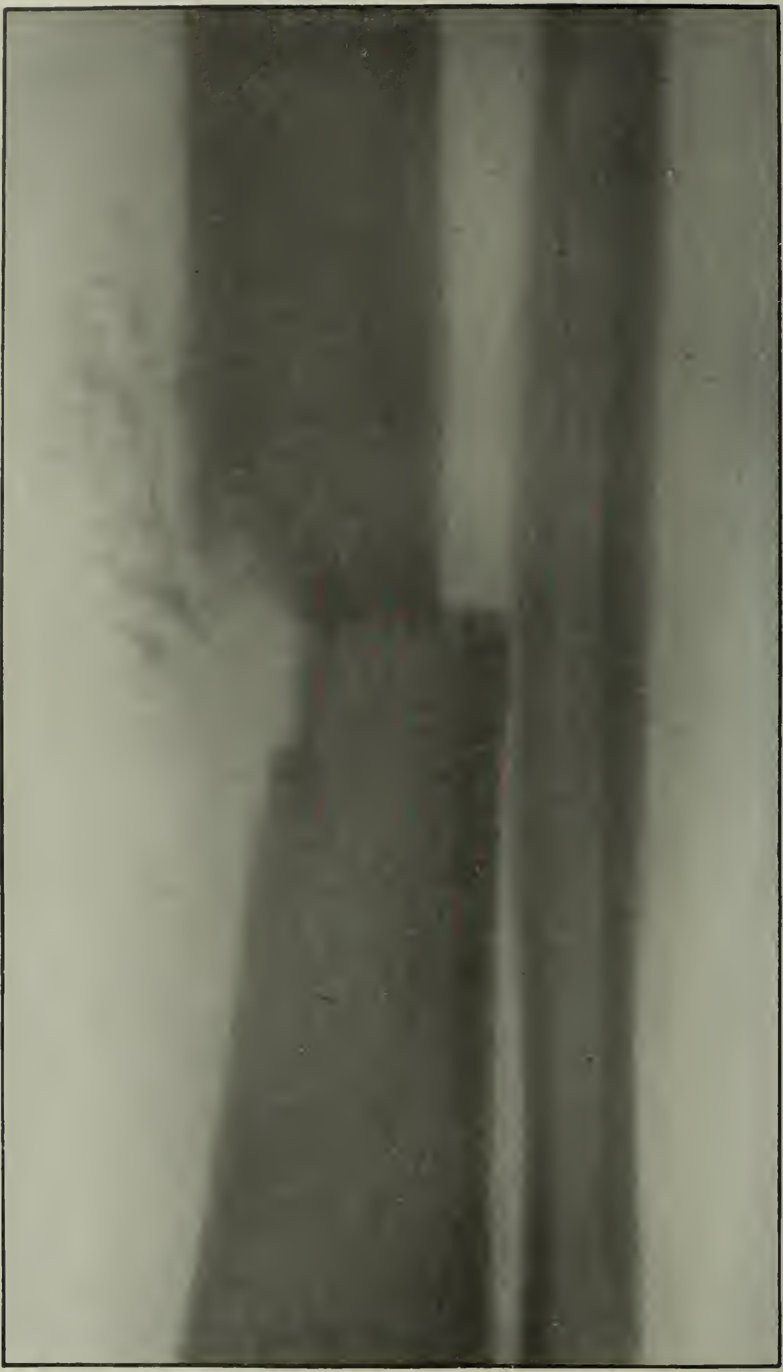
The course of the bullet was transverse, from without inward, striking on the side of the shaft of the tibia.

The bullet was so badly damaged by ricochet that only a portion of it was the cause of this wound.

The range was short, if not close, as the missile after striking a resisting object with force enough to break itself retained enough energy in a fragment of less than half its mass to cause a long fissure fracture, with the separation of smaller fragments.

The treatment is noninterference, except for infection, which, contrary to what might be expected from presumable contamination from the object from which it ricocheted, does not occur more frequently in ricochet than direct wounds with lodgment of the projectile.

Plate 67.



RIFLE—PLATE 67.

LOWER EXTREMITY.

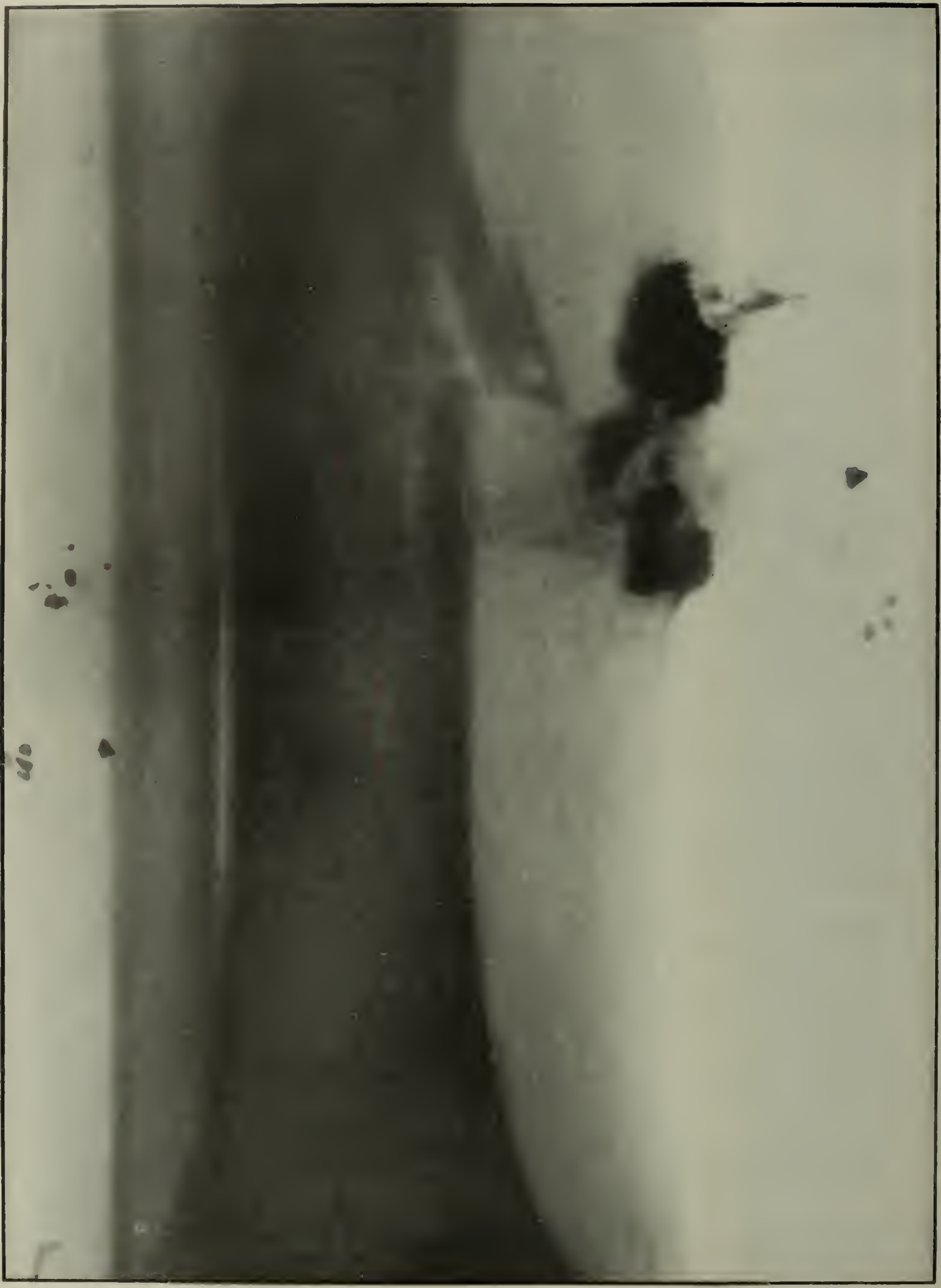
Gunshot Fracture of the Lower Third of the Tibia.

The course of the bullet, with reduced energy of long range, was anteroposterior, striking the inner border of the bone and punching out a circular area of small fragments with a single transverse line of fracture.

The wound of exit was slightly larger than the wound of entrance.

The treatment is conservative. Infection is not probable if emergency dressing is clean.

Plate 68.



RIFLE—PLATE 68.

LOWER EXTREMITY.

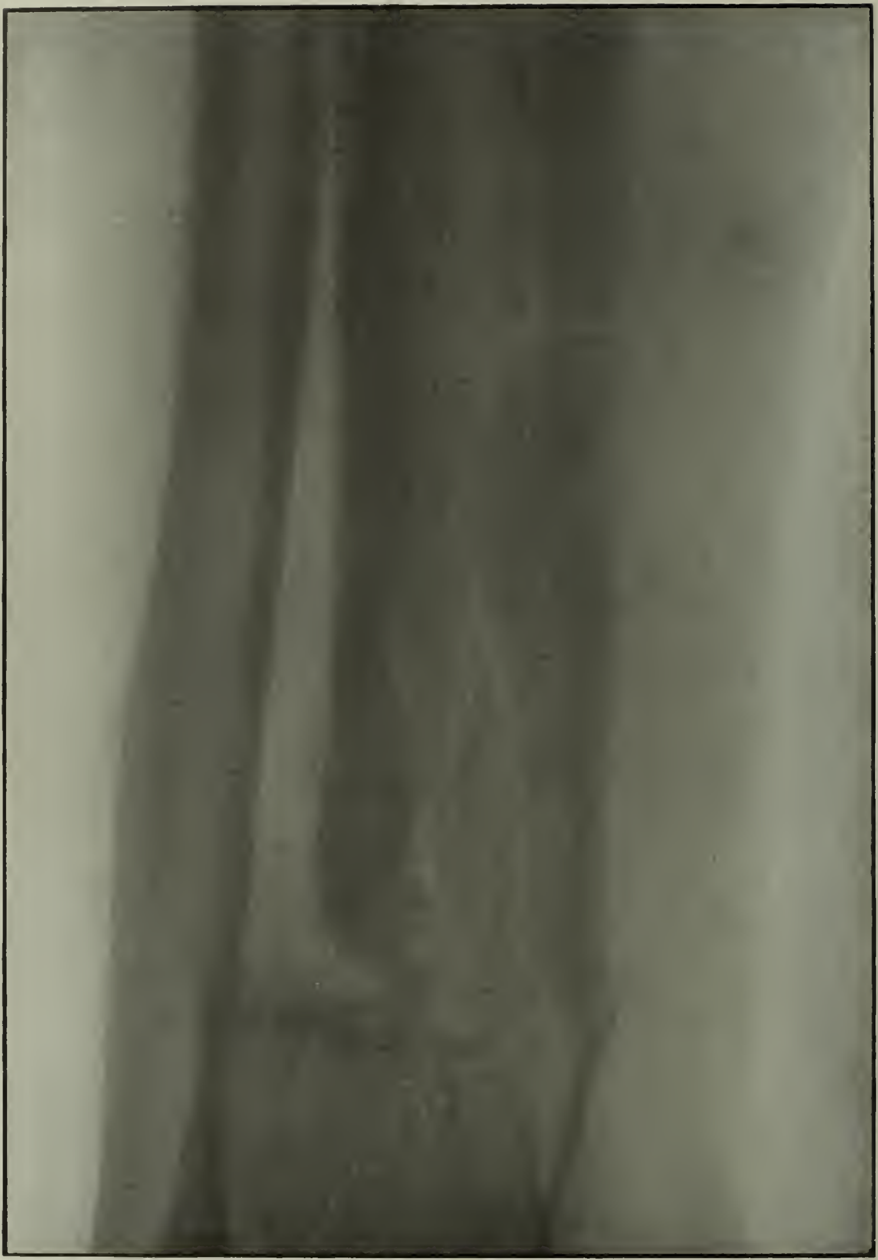
Gunshot Fracture of the Lower Third of the Tibia.

The course of the bullet was diagonally anteroposterior, from without inward, striking the internal border of the anterior surface of the bone, and partially splitting off fragments from the side with a perforating effect.

The range of the shot was long.

The dense and irregular shadows to the right of the fracture are caused by the material used in dressing and indicate a slight infection. The small shadows on the tibial side are not a part of the wound, but are due to opaque material caught in the dressing.

Plate 69.



RIFLE—PLATE 69.

LOWER EXTREMITY.

Gunshot Fracture of the Lower End of the Tibia.

The course of the bullet was transverse, from without inward, through the lower end of the bone, with a piercing effect and a fissuring of the upper fragment.

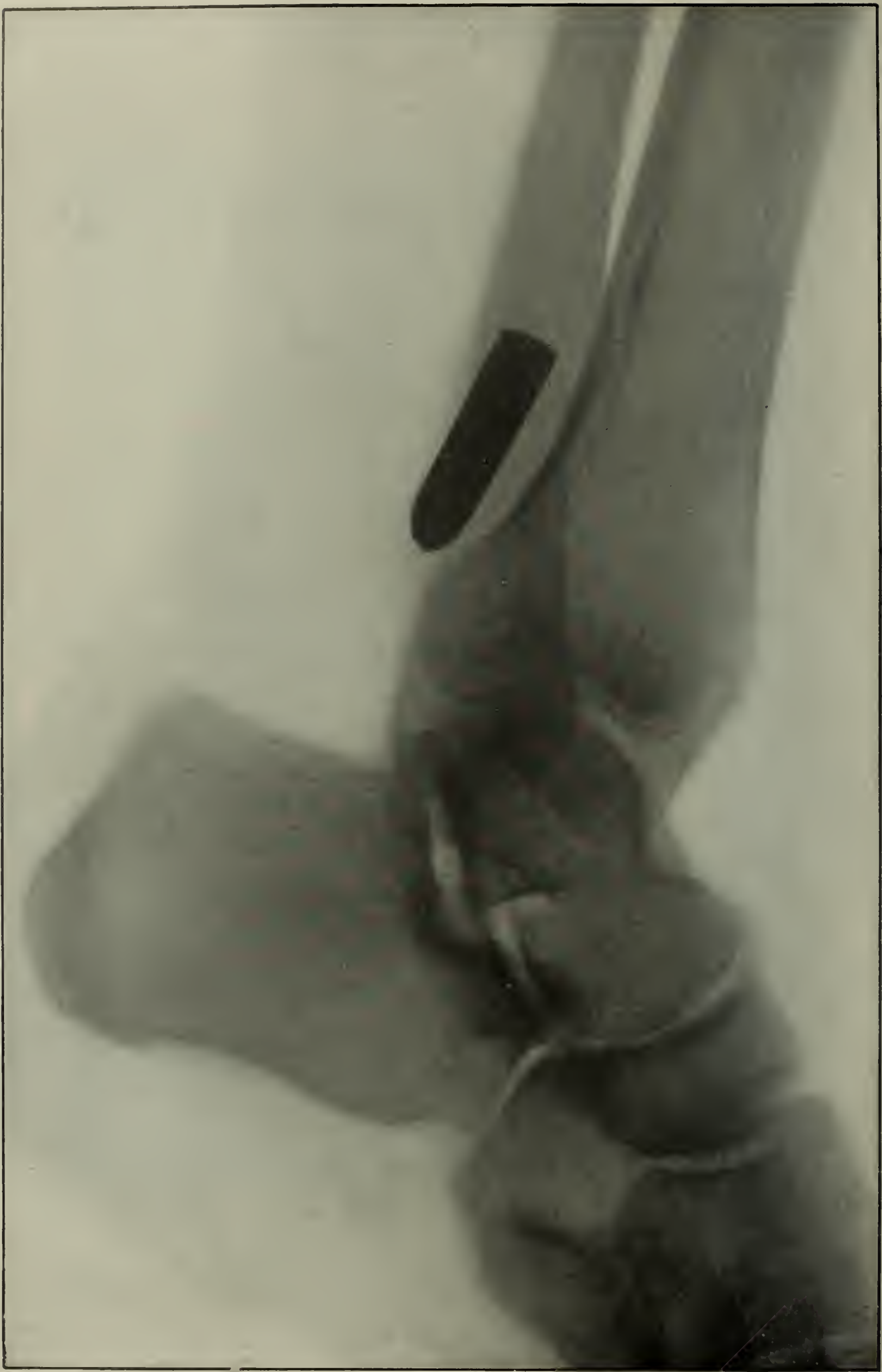
The velocity was that of short range.

The wound of exit would be slightly larger than that of entrance, as some small fragments can be seen extending along the tract of the missile from the line of transverse fracture toward the internal border of the leg. There was no laceration of the wound of exit. The wound was clean.

The treatment is conservative.

Results should be favorable. Infection would depend most probably upon the asepsis of the first dressing.

Plate 70.



Rifle—Plate 70.

LOWER EXTREMITY.

Gunshot Fracture of the Tibia, with Lodgment of the Missile.

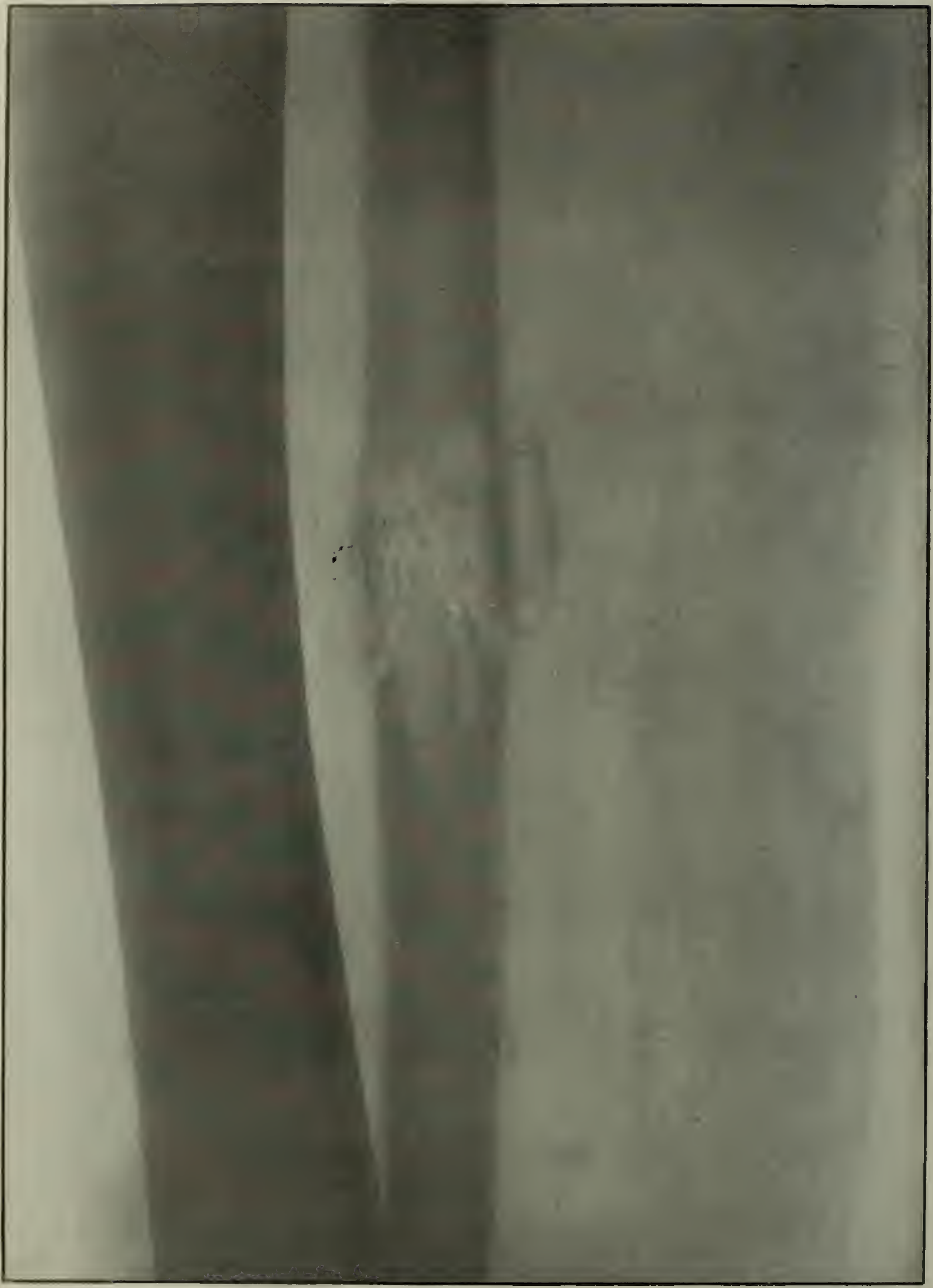
The course of the bullet was from within outward, striking the posterior surface of the tibia about 2 inches above the ankle, and causing a slight crack in the bone at the point where its course was deflected.

The velocity was that of extreme range, as the wholly normal outline of the projectile and the slight penetration indicates that its energy was almost entirely lost in flight and not by ricochet.

The sharp outlines of the lower border of the fibula and the external border of the articular surface of the lower end of the tibia indicate the position of the fibula as next to the photographic plate.

The bullet lies at a very slight angle with the plate, as is shown by the curved outline of its base, which condition alone would give a projection shadow somewhat shorter than the bullet. But as the shadow is actually somewhat longer than the bullet (about one-eighth inch, or one-tenth its length), the position of the bullet is some distance from the plate and most probably lies behind the tibia, at the inside of the fibula.

Plate 71.



Rifle—Plate 71.

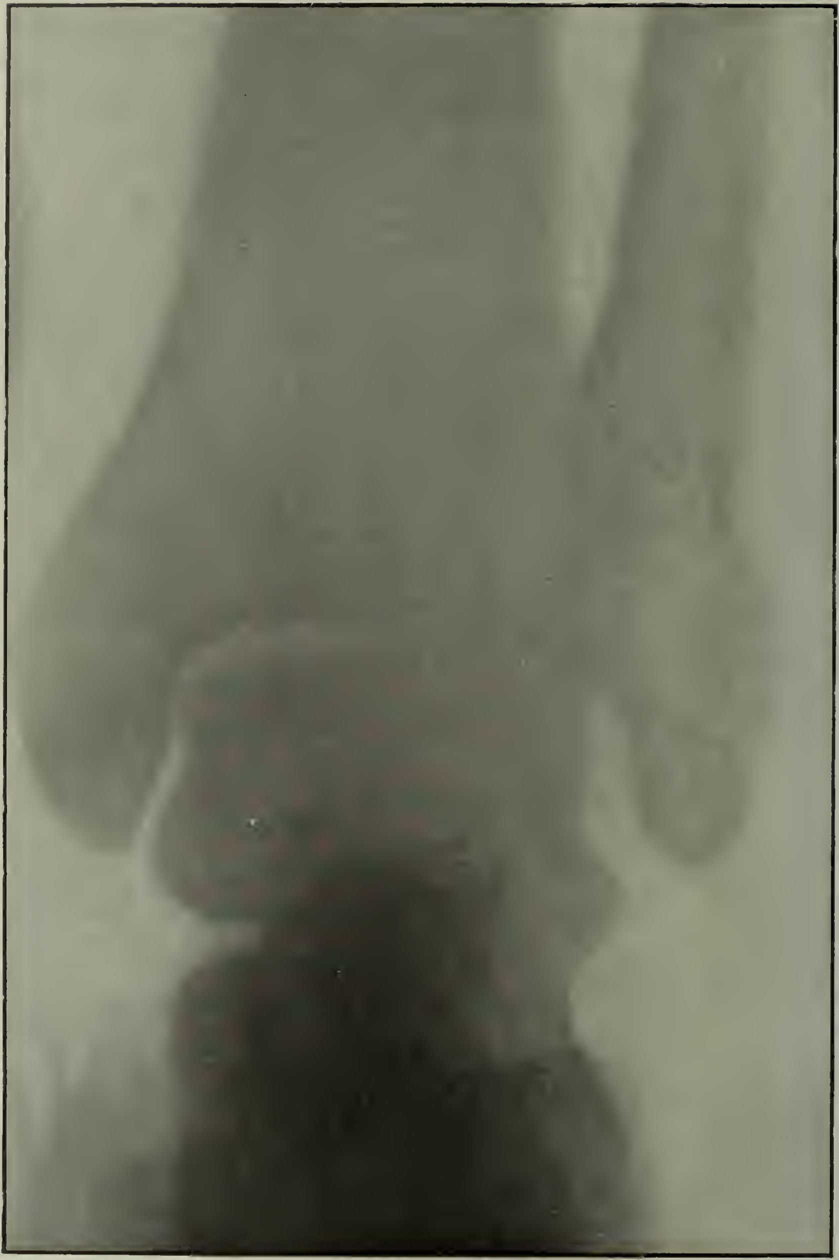
LOWER EXTREMITY.

Gunshot Fracture of the Fibula.

The course of the bullet was anteroposterior through the lower third of the leg, striking the fibula squarely, passing through the bone with a perforating effect, accompanied by slight fragmentation and with a reduced velocity of long range.

The wounds of entrance and exit would be almost the same in appearance. Asepsis in such cases is the almost invariable rule, and the treatment after the simple dressing is that of a simple fracture.

Plate 72.



Rifle—Plate 72.

LOWER EXTREMITY.

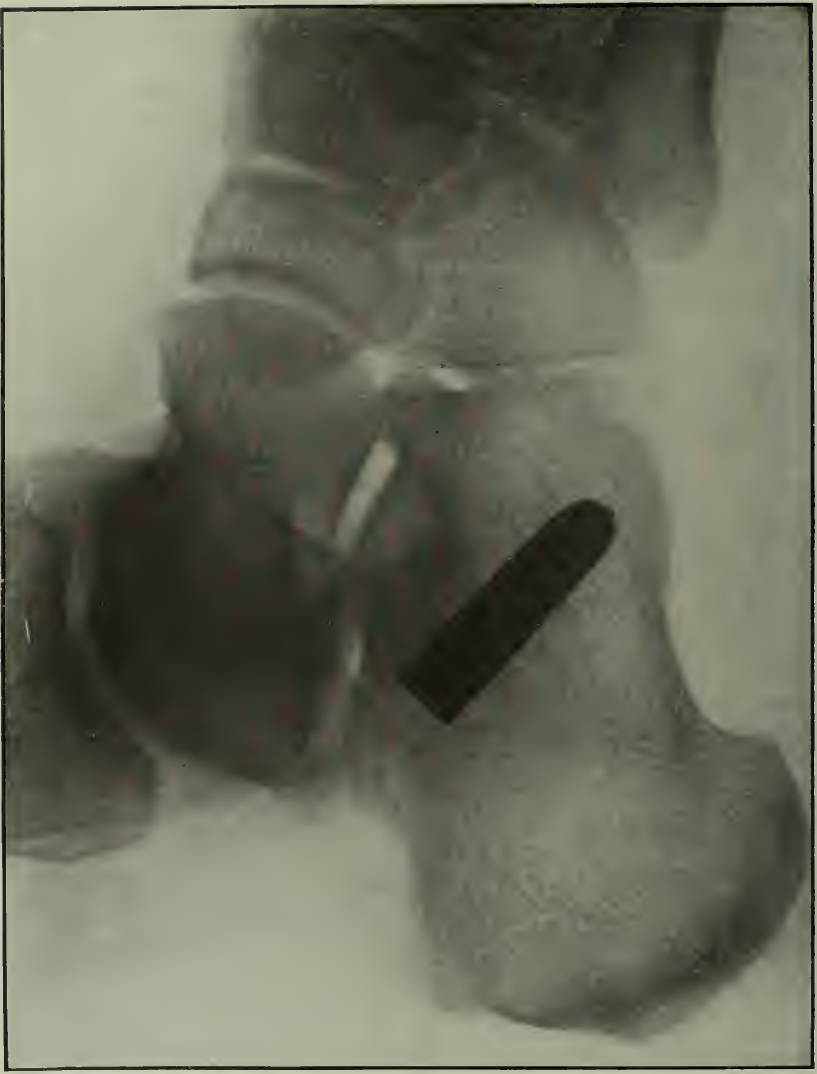
Gunshot Fracture of the Ankle.

The course of the bullet was anteroposterior, striking the fibula from behind with a velocity of long range, and causing some slight fragmentation without displacement of the fragments.

The joint architecture is slightly disturbed. The joint mortice is a bit widened by the external deflection of the external malleolus, which permits a slight outward rotation of the astragalus.

As the dangers of infection are usually escaped, the treatment is that for Pott's fracture.

Plate 73.



Rifle—Plate 73.

LOWER EXTREMITY.

Gunshot Wound of the Heel, with Lodgment of the Missile.

The course of the bullet was from behind forward through the insertion of the tendo Achillis and its lodgment along the outer border of the os calcis.

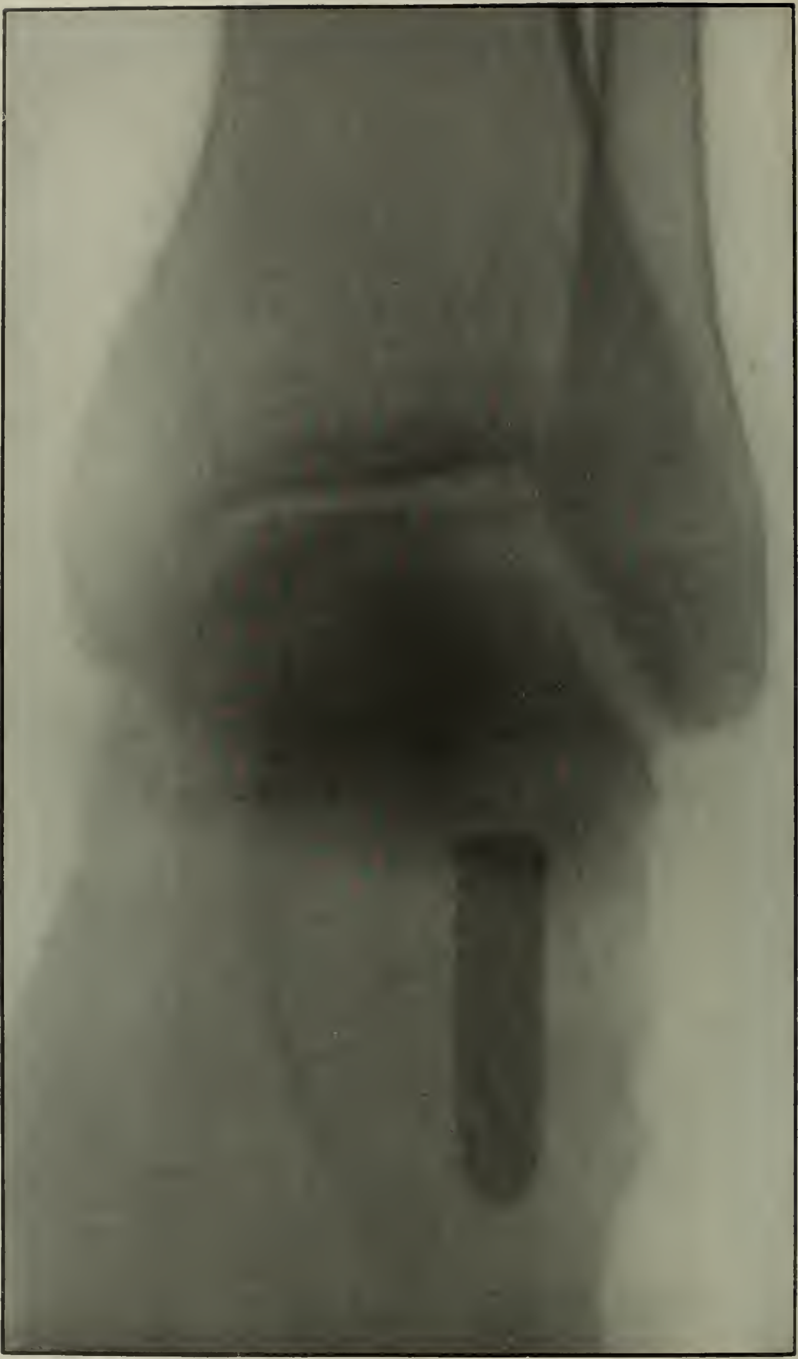
There was no injury to the bone. The path of the bullet is shown by the slight mottling above the posterior extremity of the os calcis.

The nose of the bullet is slightly deformed by ricochet at long range.

The very slight penetration and the slight deformity of the nose of the bullet indicates a velocity of extreme range of both impact of the ricochet and of the wound.

The sharp outline of fibula and the base of fifth metatarsal shows the fibula to be next to the plate. The only slight enlargement and square base of the shadow of the bullet show it to be parallel to the plate, or at right angles to the line of projection, and thus indicate its position to be on the fibula side of the os calcis, below the tip of the external malleolus.

Plate 74.



RIFLE—PLATE 74.

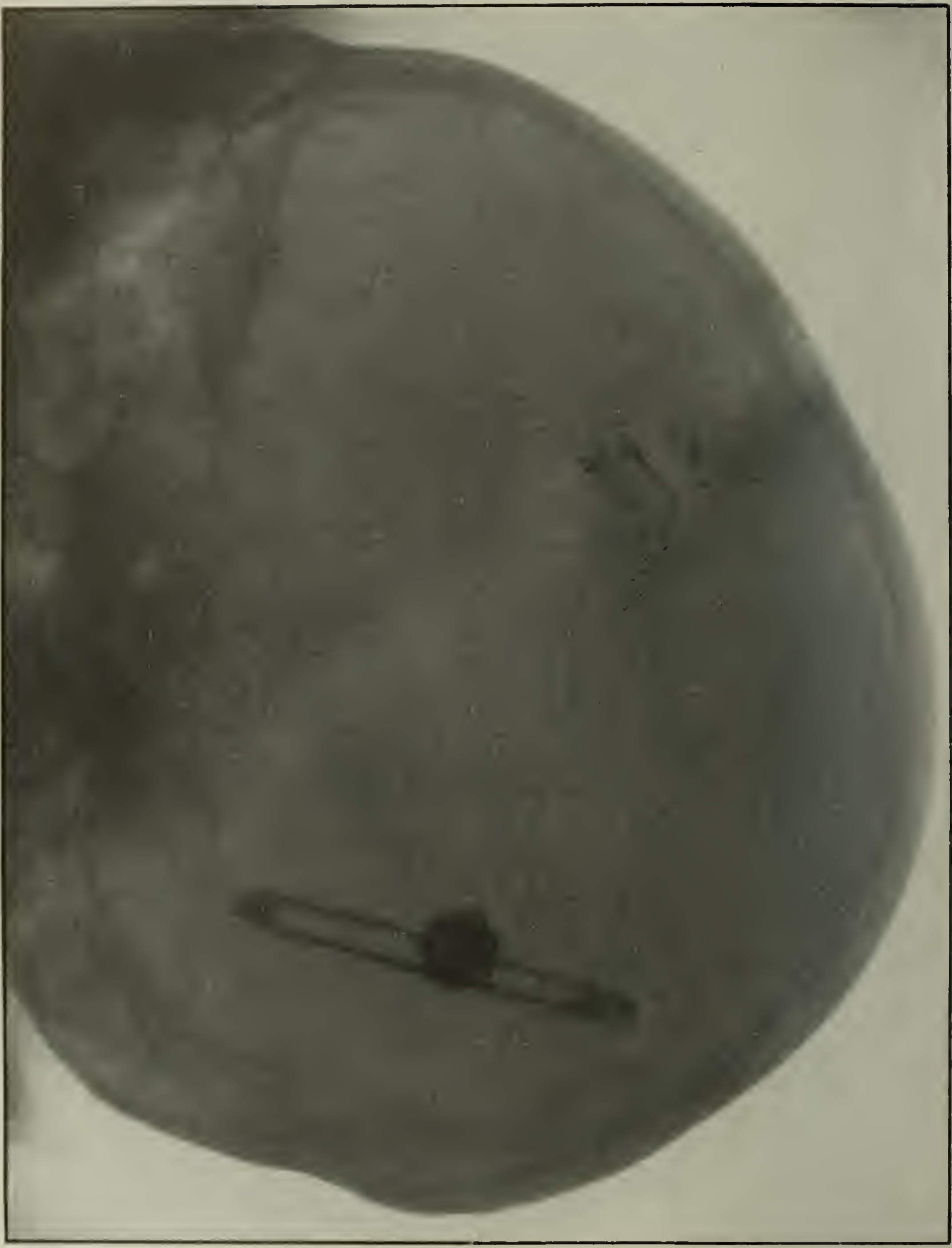
LOWER EXTREMITY.

Gunshot Wound of the Heel.

This is the same case as shown in plate 69, but with the shadow projected from above downward instead of from side to side, as in the preceding plate. The interpretation of the shadows in the preceding plate is thus confirmed.

As the heel lay on the plate, the projectile at a sharp angle with the plane of the plate, several inches farther from the plate than in the preceding radiograph, and with the line of projection at about right angles to the long axis of the projectile, the shadow projection is considerably enlarged.

Plate 75.



Shrapnel—Plate 75.

HEAD.

Gunshot Fracture of the Vertex, with Intracranial Lodgment of the Missile.

Wound of entrance, left anterior parietal region.

Wound of exit, none.

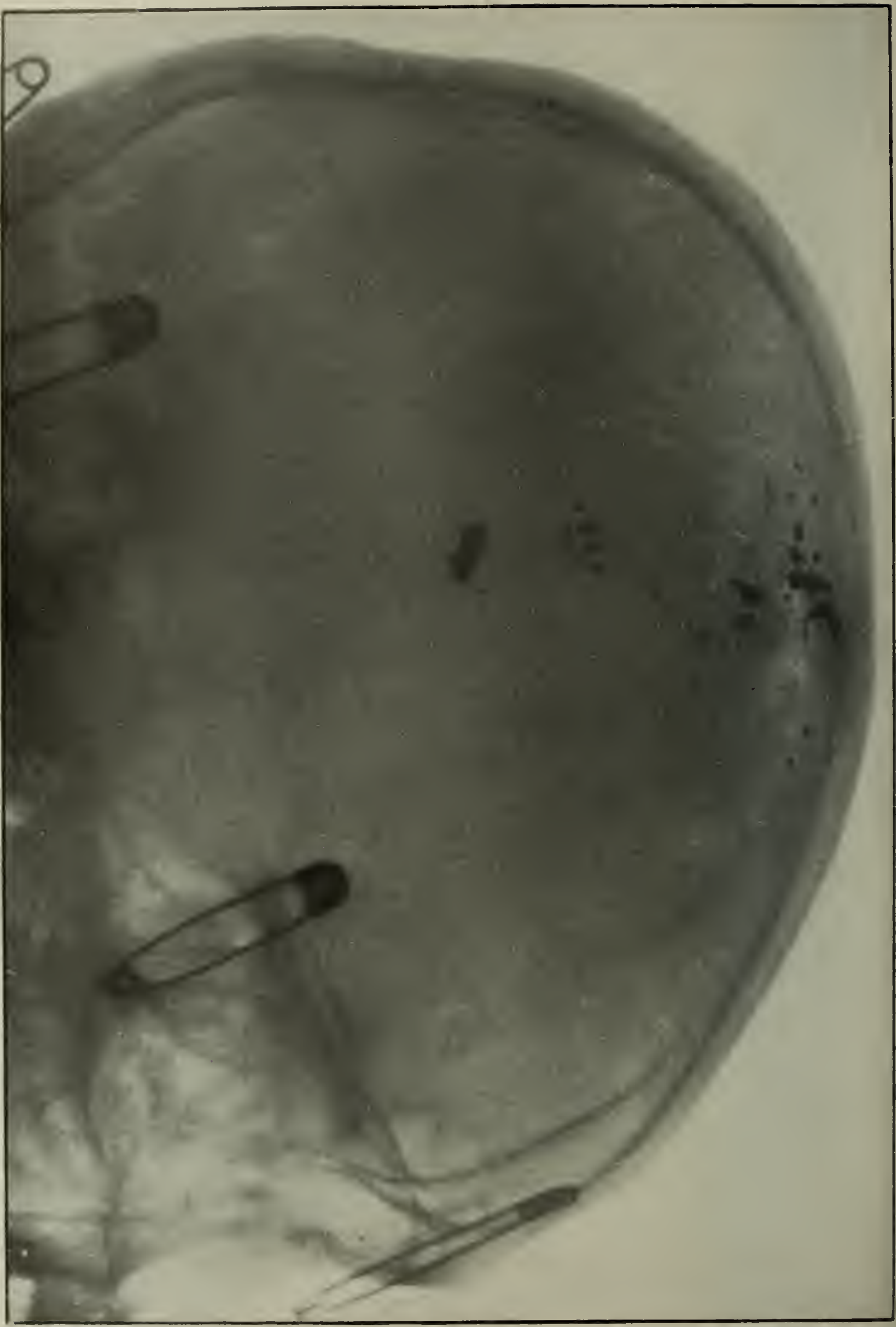
The missile left a few small fragments spattered on the bone at point of entrance, with a slight deformation of the ball due to this cause, as shown in the plate.

The distinct outline and normal size of the ball shows it to be very near the plate and on the left side of the head, while the enlarged and blurred image of the safety pin shows its position to be on the side of the head farther away from the plate.

Emergency treatment is antiseptic dressing only. Subsequent treatment is directed to fragments and depression, without search for ball. Septic condition might indicate some later interference.

Results in such cases are favorable if wound is not infected.

Plate 76.



SHRAPNEL—PLATE 76.

HEAD.

Gunshot Fracture of the Vertex.

Wound of entrance, upper right and mid-parietal region.

Wound of exit, none.

The missile probably was deformed before striking the skull, upon which it was fragmented by impact, with several fragments following the internal contour of the vertex and others remaining spattered about the wound of entrance.

It is probable that a larger mass of the shrapnel ball, causing the greater damage to the bone, ricocheted out of the wound.

The distinct outline of the central safety pin and the less definite image of the shrapnel fragments show the wound to have been farther from the plate than the safety pin on the left side.

The treatment is expectant, without search for the missile.

Results in such cases are favorable, except for danger of infection.

Plate 77.

SHRAPNEL—PLATE 77.

HEAD.

Gunshot Fracture of Zygoma, with Lodgment of the Missile in the Zygomatic Fossa.

Wound of entrance, external border of right supra-orbital ridge.

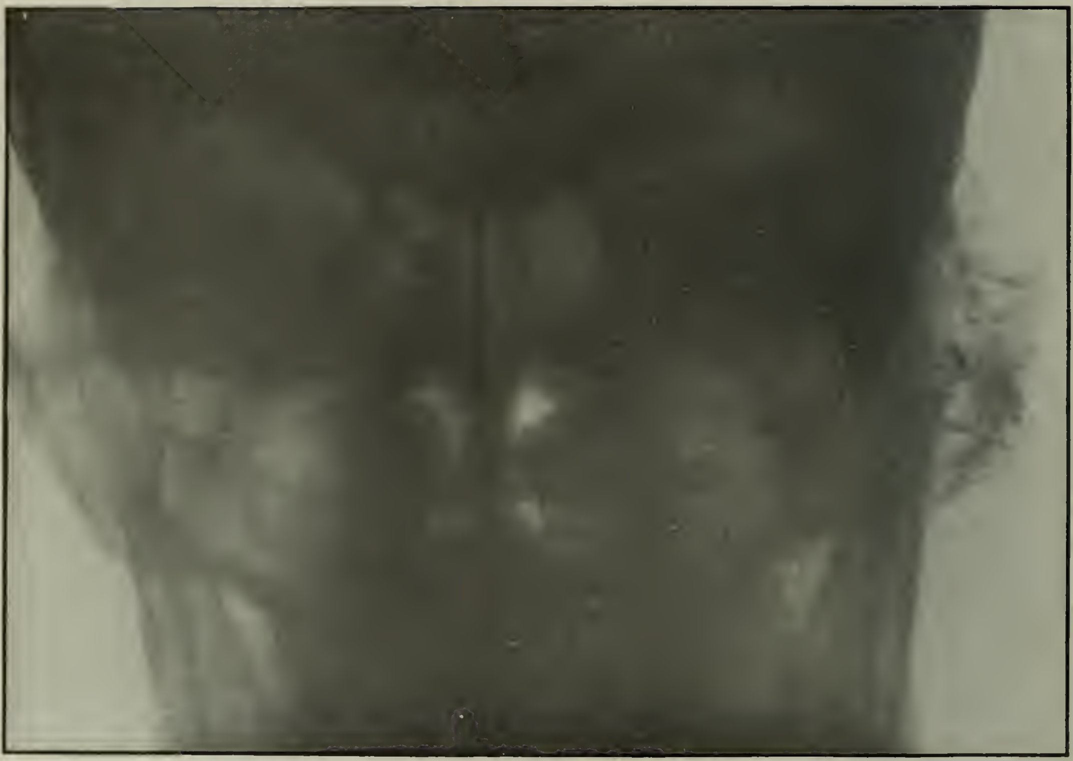
Wound of exit, none.

A few metallic fragments are seen where the missile lodged near the point of impact with the bone.

The treatment is expectant. Removal of the ball from its superficial location is indicated if the wound is infected.

Result in such cases is favorable.

Plate 78.



SHRAPNEL—PLATE 78.

HEAD.

Gunshot Fracture of the Mastoid Process.

Wound of entrance, upper posterior cheek, in front of the ear.

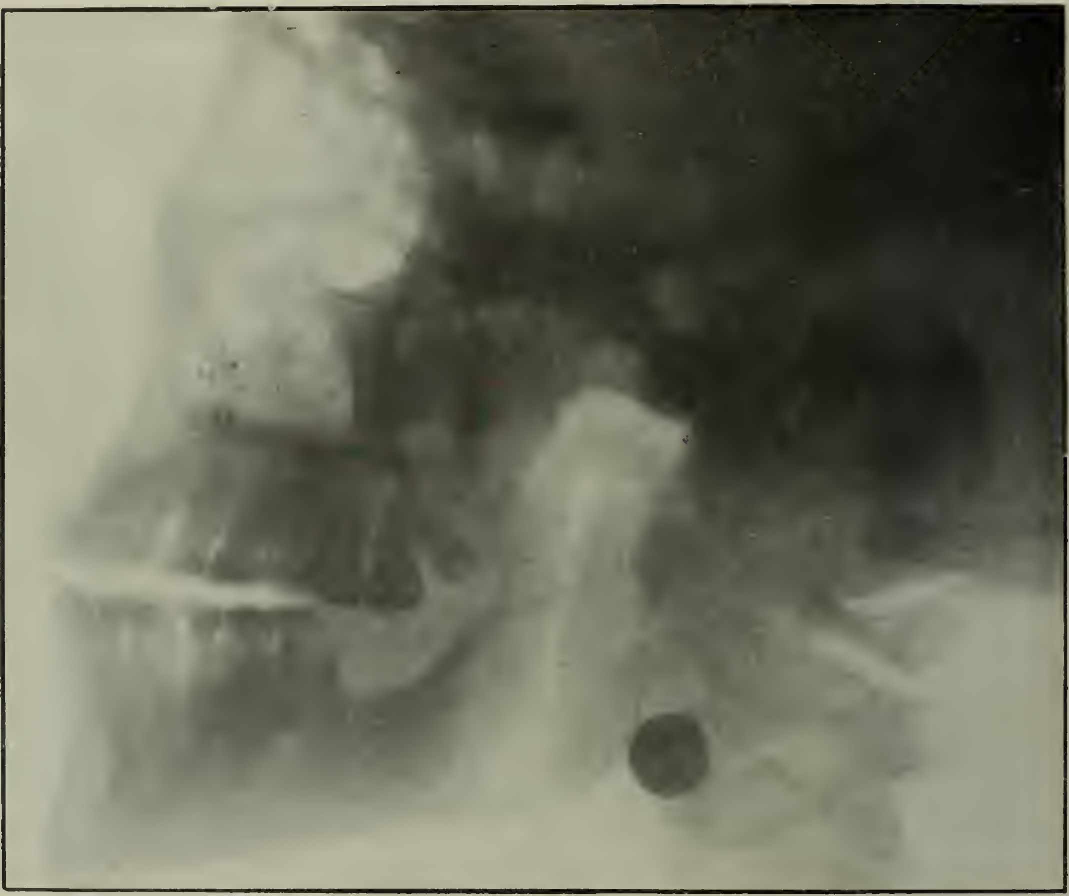
Wound of exit, posterior to mastoid process, lacerated.

The course of the missile was tangential, with the damage limited to the outer table of the mastoid. The metal particles scraped off of the ball by its contact with the bone mark the site of the wound.

Treatment is expectant.

Results are favorable.

Plate 79.



SHRAPNEL—PLATE 79.

HEAD.

Gunshot Fracture of the Left Maxilla, with Lodgment of the Missile in the Neck Behind the Angle of the Jaw.

Wound of entrance, below infraorbital ridge, with course through the mouth.

Wound of exit, none.

Missile left a few small metallic fragments spattered on the bone at the point of entrance. There is slight mark of deformity of the missile caused by its contact with the bone, shown in its shadow in the plate.

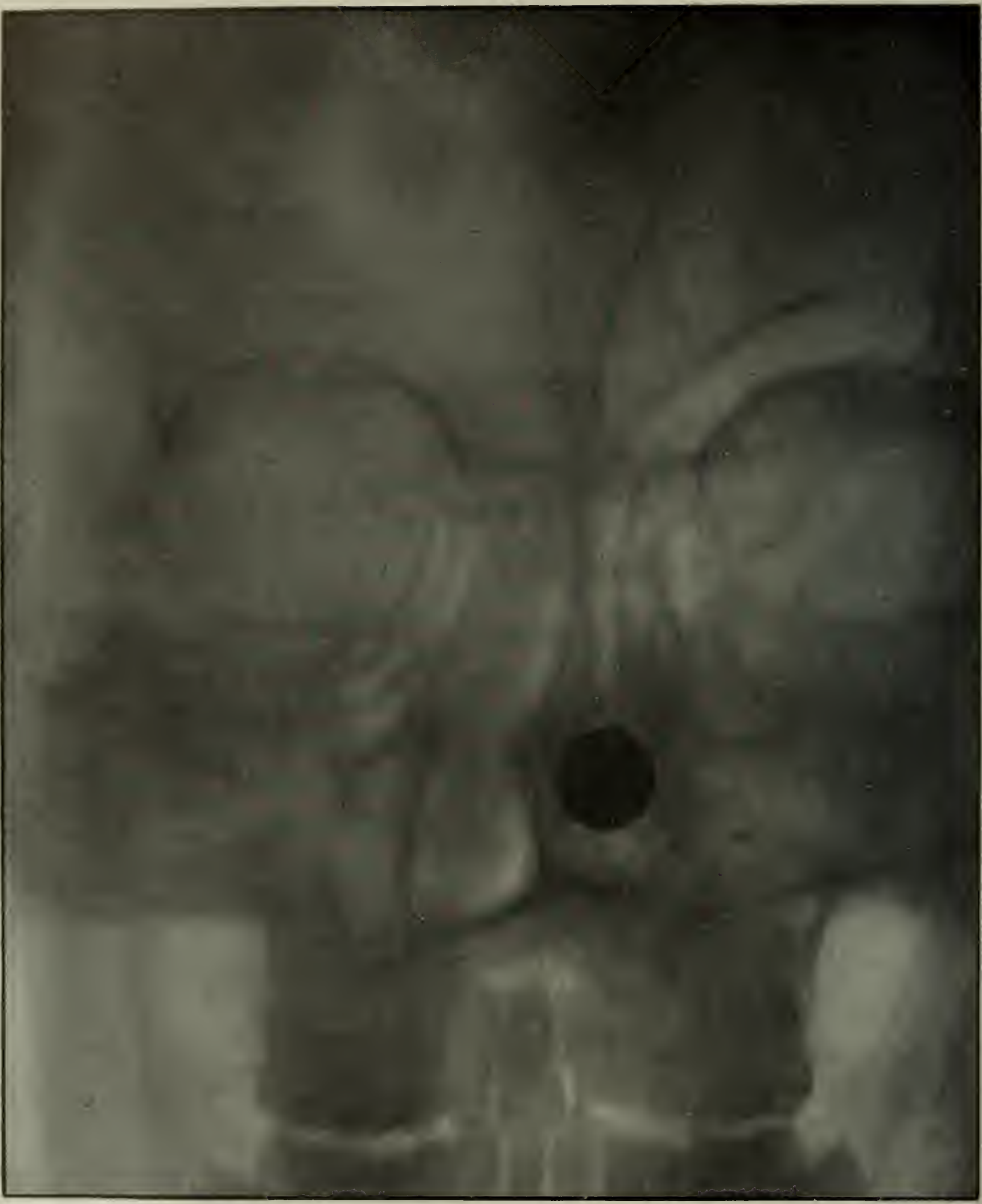
The distinct outline and normal size of the ball shows it to have been on the side next to and near the plate.

Treatment indicated is expectant.

Results in such cases are favorable, as seat of probable infection is readily accessible.

In this particular case, recovery followed with the ball left *in situ*, without causing the patient trouble enough to induce him to permit interference.

Plate 80.



HEAD.

Gunshot Fracture of the Anterior Table of the Frontal Sinus, with Lodgment of the Missile in the Posterior Nares.

Wound of entrance, over the left internal super supra-orbital ridge, with course downward, slightly backward, and slightly to the left posterior nares.

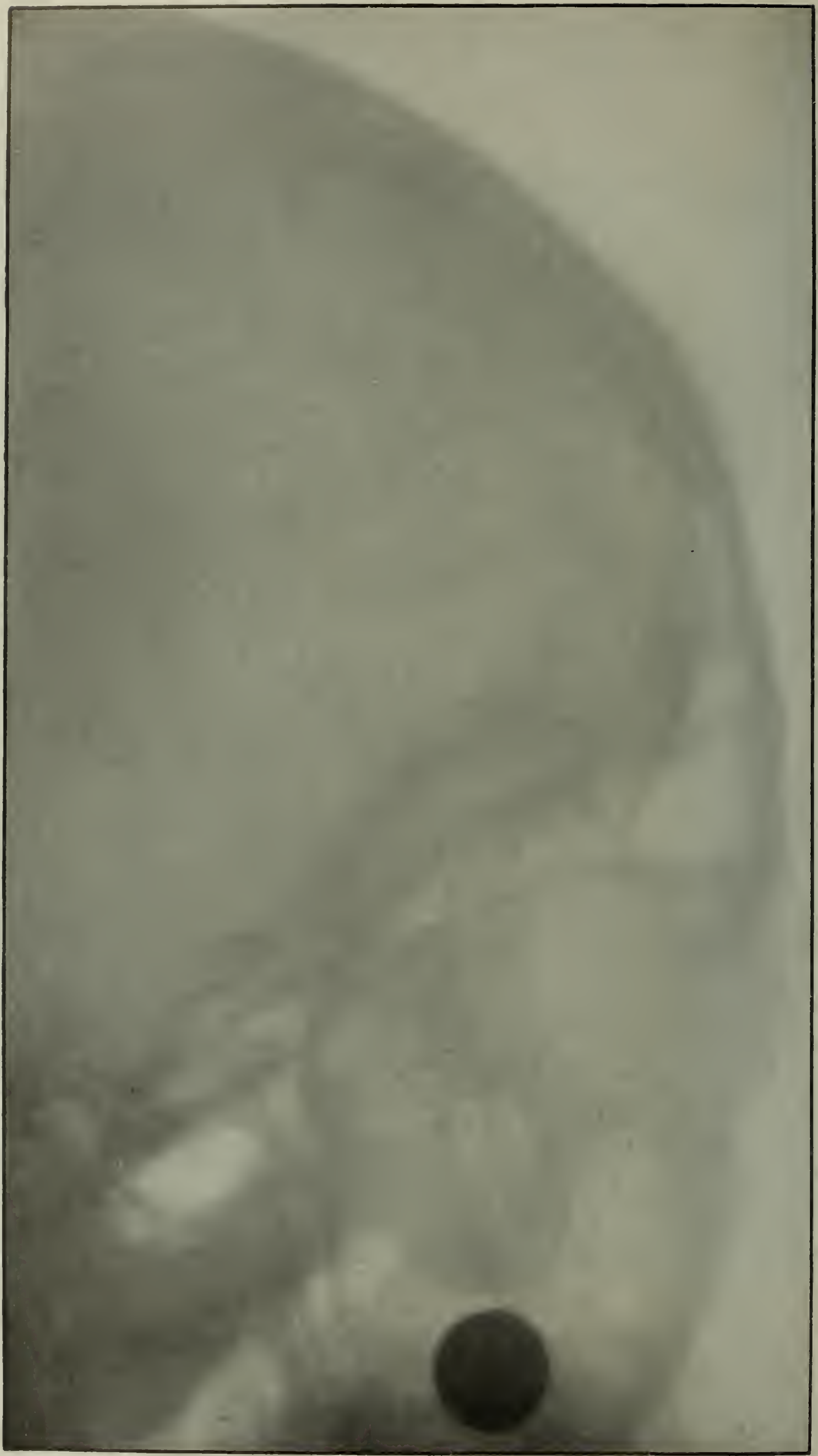
Wound of exit, none.

The distinct outline and practically normal size of ball shows that the patient's face was superimposed on the photographic plate, as the anterior location of the missile was suspected. The slight deformity of the ball is due to the impact with the bone. This personal case was received from the service of Prof. De Page, of the Belgian Red Cross Mission, at Josh Keshla Hospital, Constantinople, after an operation for infections of the frontal sinus, in which the anterior table was entirely removed, with free drainage into the posterior nares, before the radiograph was made or the exact location of the ball suspected. The missile is seen in the nares—very near the face—probably in the middle meatus, in the inferior turbinates, against the septum, deviated by its lodgment.

Convalescence was finally established and the frontal-sinus wound practically closed when, without any subjective symptoms, an obstruction was objectively determined in the left posterior nares, suggesting the radiograph.

The patient was so entirely free from any symptoms of the lodged missile that he wisely refused any meddlesome interference. He was discharged with sinus wound closed very remarkably without indication for plastic operation and with no symptoms.

Plate 81.



SHRAPNEL—PLATE 81.

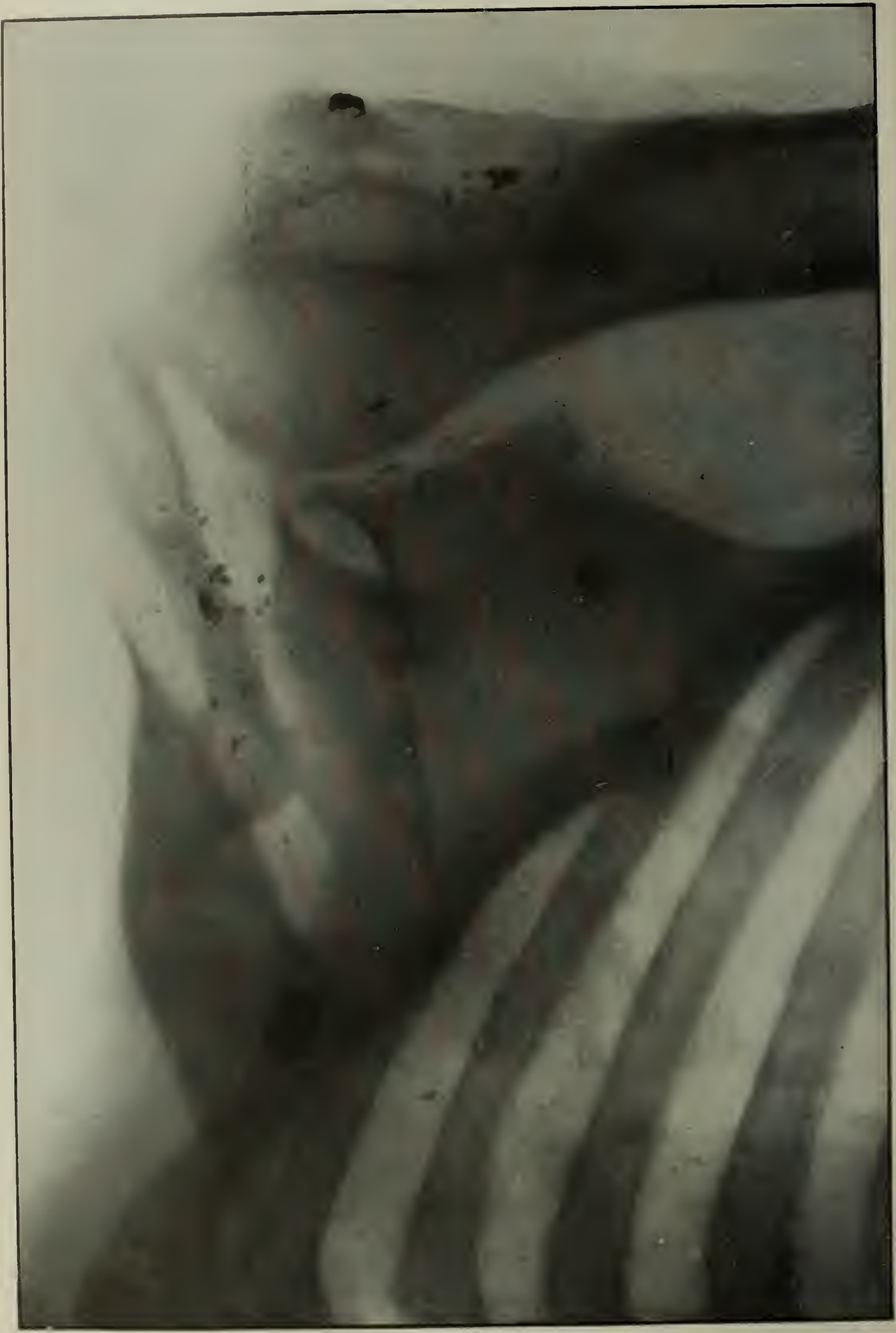
HEAD.

Gunshot Fracture of Anterior Table of the Parietal Bone and the Vomer, with the Lodgment of the Missile in the Posterior Nares.

This plate is a side view of the case in plate No. 81, showing the antero-posterior location of the ball.

The indefinite outline and enlarged size of the ball shows the ball to have been farther away from the plate than in plate 80.

Plate 82.



SHRAPNEL—PLATE 82.

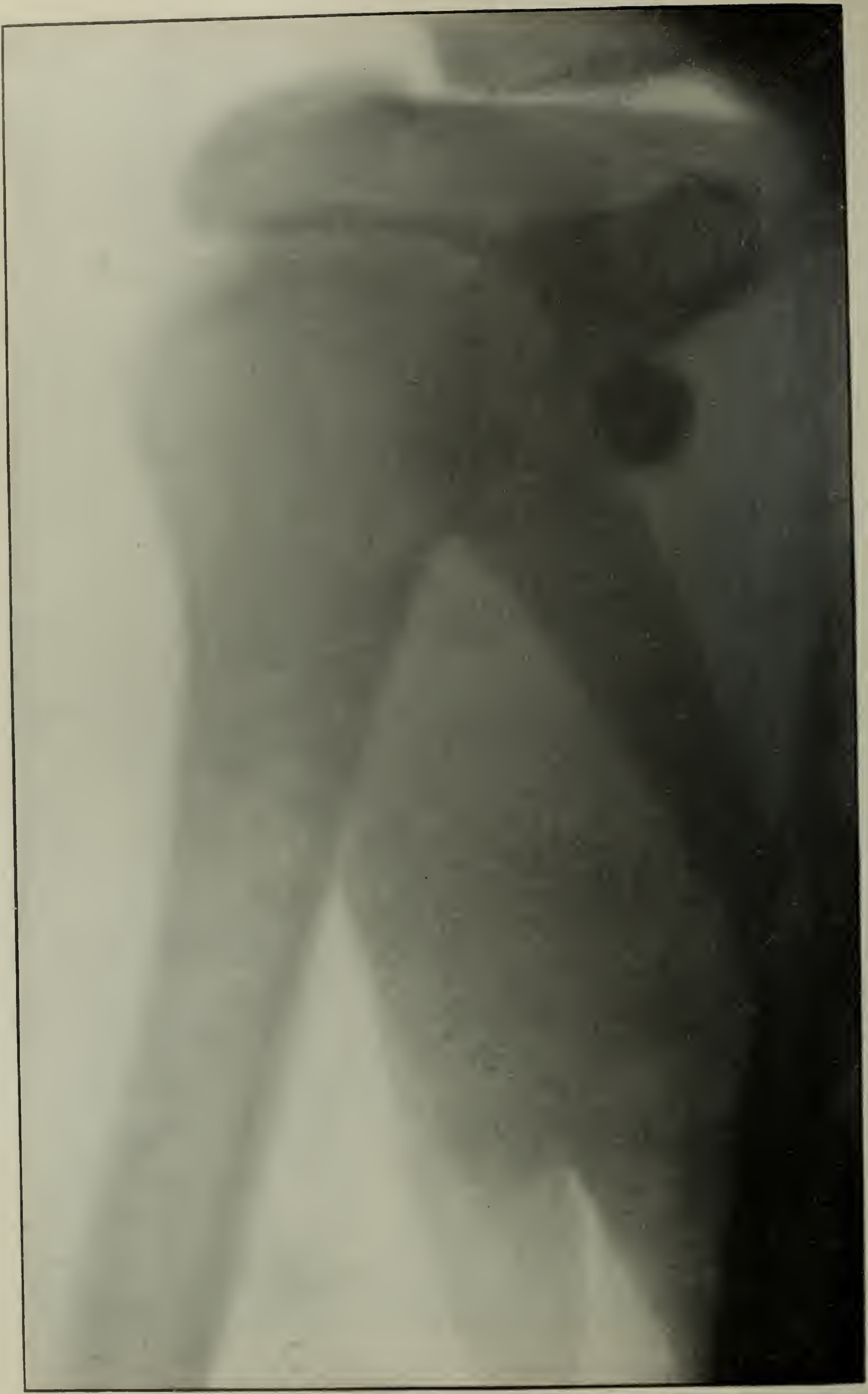
UPPER EXTREMITY.

Gunshot Wound of the Shoulder, with Lodgment of the Missile.

The course of the missile was transverse from the posterior surface of the greater tuberosity of the humerus to the internal border of the scapula, distributing small metallic fragments along its path.

There is no injury to the bone. The remnant of the ball has passed behind the scapula and lies near its superior angle.

The treatment in such cases is, of course, conservative, with no serious consequences expected from infection.



UPPER EXTREMITY.

Gunshot Wound of the Shoulder, with Lodgment of the Missile.

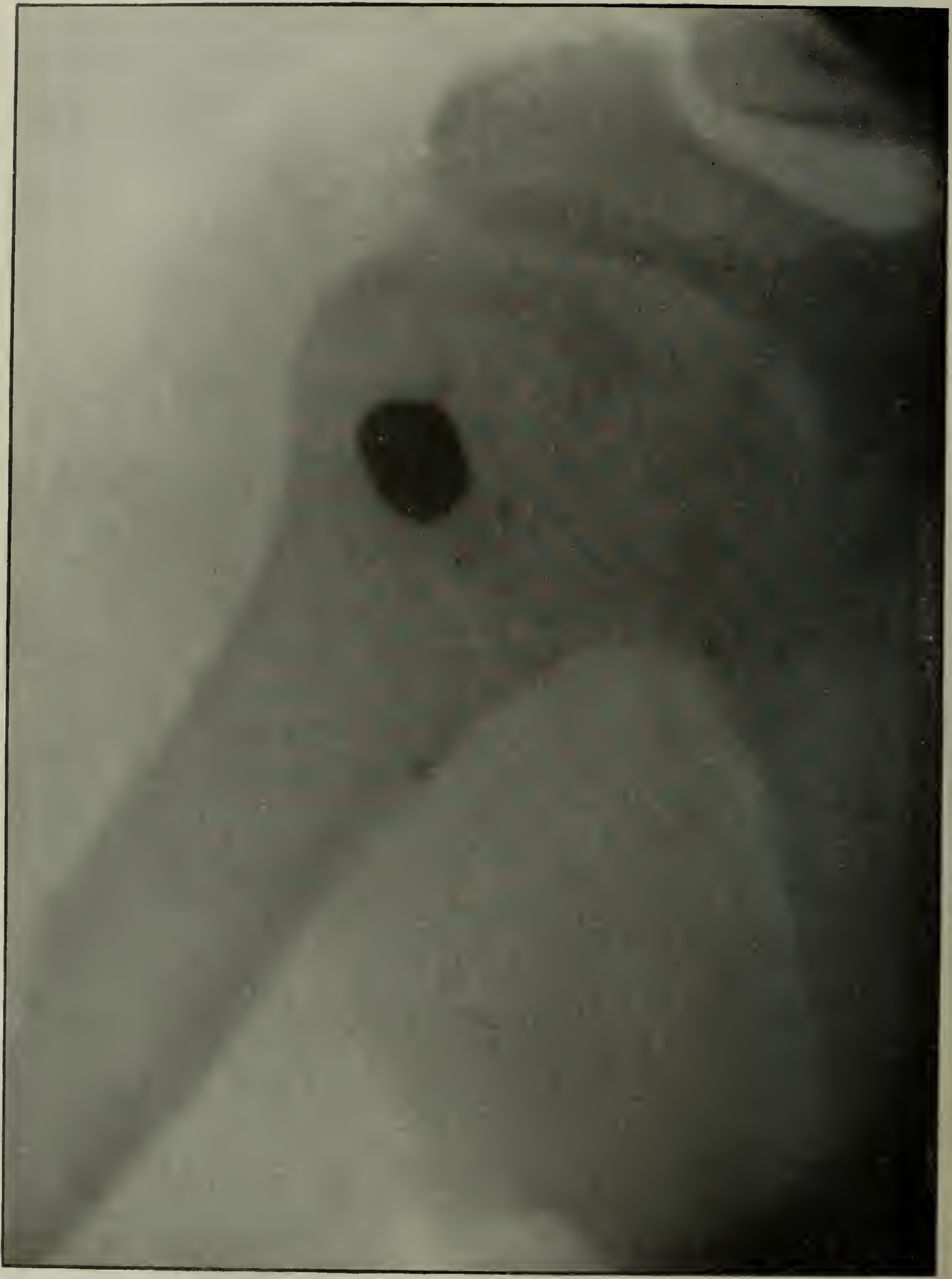
The course of the ball was transverse through the posterior border of the deltoid muscle without contact with the bone, which would have been revealed by small particles of lead scraped off from the ball.

The actual size, normal outline, and great density of the shadow of the ball show that it lay next to the plate and that it is, therefore, lodged posterior and mesial to the glenoid portion of the scapula.

The treatment is noninterference unless removal be indicated by pain, impairment of function, or infection.

The results should always be good.

Plate 84.



SHRAPNEL—PLATE 84.

UPPER EXTREMITY.

Gunshot Wound of the Shoulder, with Lodgment of the Missile.

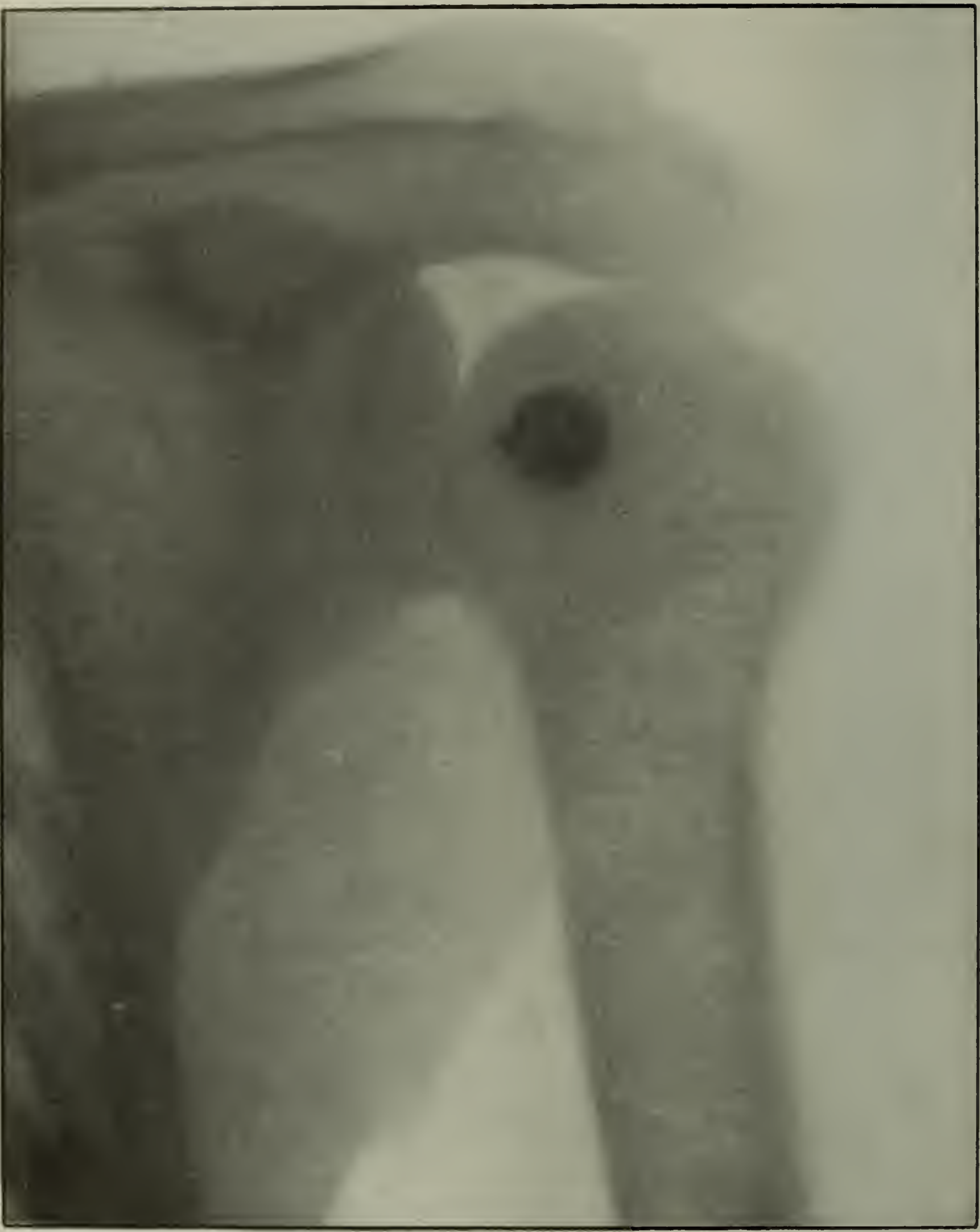
The course of the bullet was from before backward and upward through the deltoid to the anterior surface of the head of the humerus.

The missile is not the conventional shrapnel ball, which is spherical and about one-half inch in diameter, for the shadow shows a larger axis in one direction with parallel sides, too symmetrical to be attributed to deformation. The ballistic conditions are those of shrapnel.

The missile struck the bone an inch or two below the point of lodgment. Its path is shown by particles of metal.

Pain or interference with function would be cause for interference in subsequent treatment, which otherwise would be expectant.

Plate 85.



SHRAPNEL—PLATE 85.

UPPER EXTREMITY.

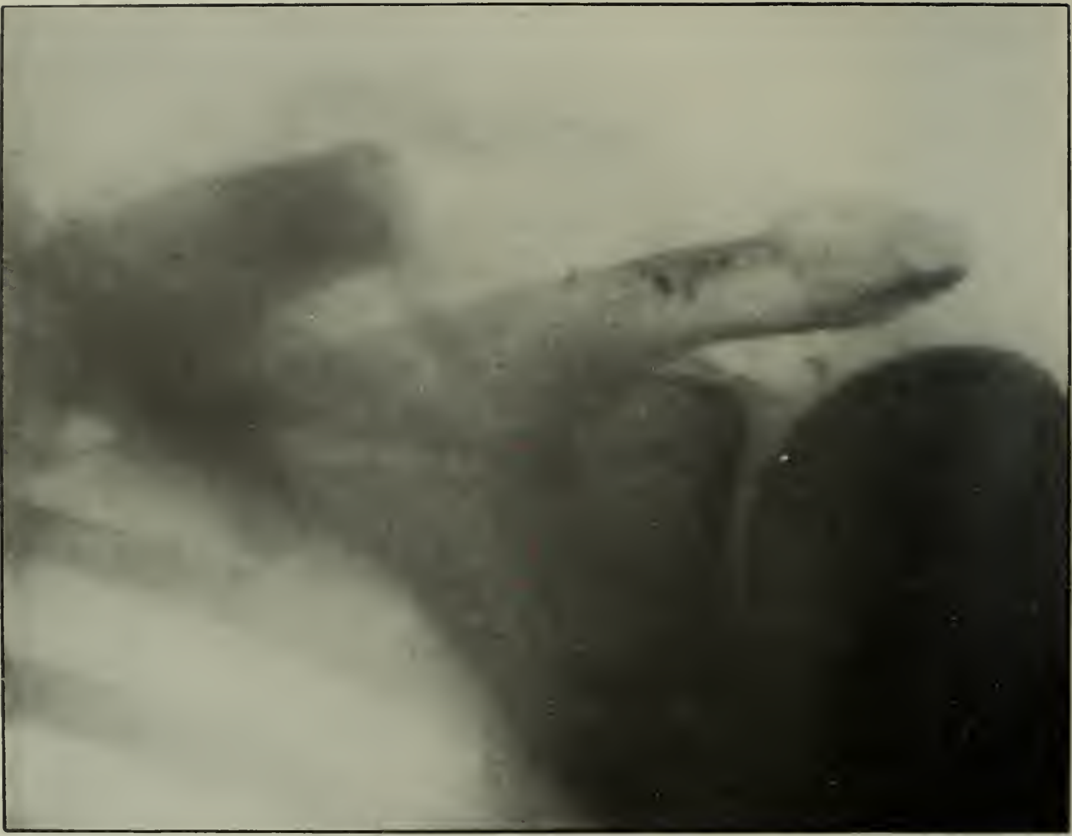
Gunshot Wound of the Shoulder, with Lodgment of the Missile.

The missile lies behind the head of the humerus, under conditions similar to the cases shown in plates 85 and 86.

The position of the ball is indicated by the outline and depth of shadow of the normal size of a shrapnel ball. The ball must therefore be very near the plate and behind the head of the humerus.

There is no injury to the bone. The slight deformity of the ball was caused by ricochet before it caused the wound, as no particles of lead are seen on the bone to account for the impact of the missile.

Plate 86.



SHRAPNEL—PLATE 86.

UPPER EXTREMITY.

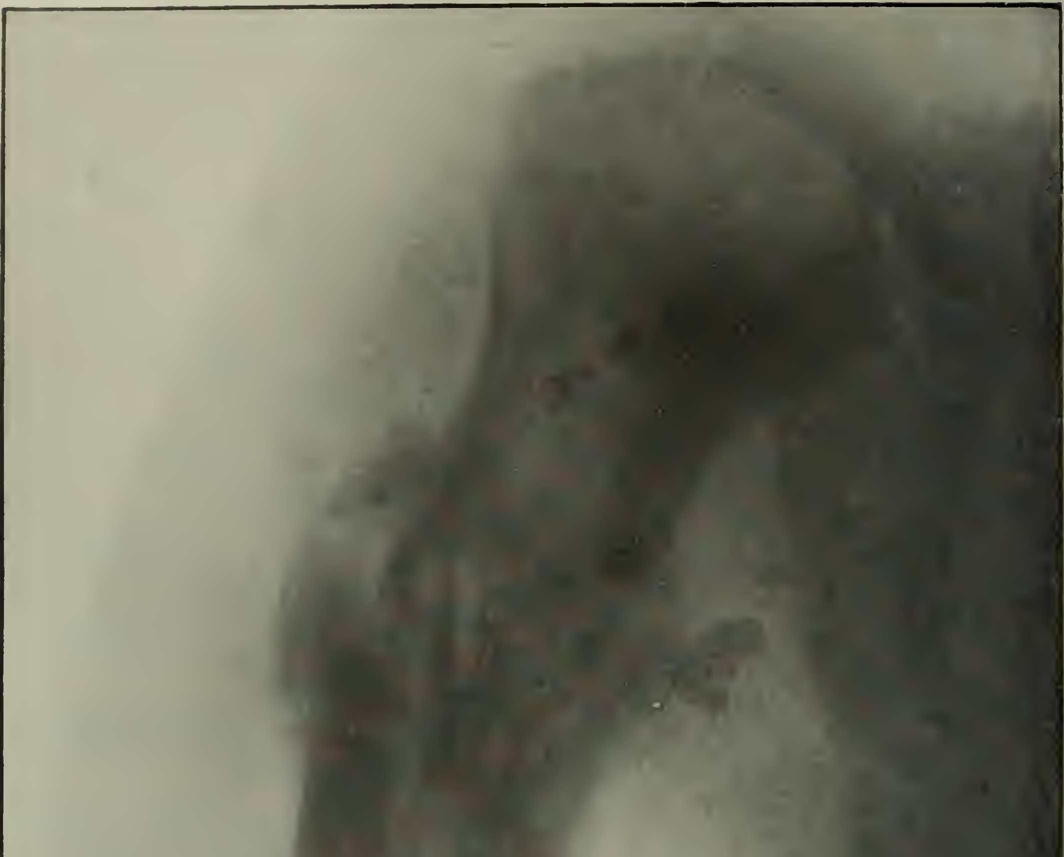
Gunshot Fracture of the Clavicle.

The ball ranged from before backward and upward, comminuting the outer half of the clavicle.

The fragments have been removed. The particles of metal which mark the path of the ball lie in front of the acromion process of the scapula, because lack of density and indistinct outline of the shadows show them to be farther from the photographic plate than the spine of the scapula which rested on the plate, escaping the imminent danger of wounding the subclavian vessels.

The treatment is conservative and results are favorable.

Plate 87.



SHRAPNEL—PLATE 87.

UPPER EXTREMITY.

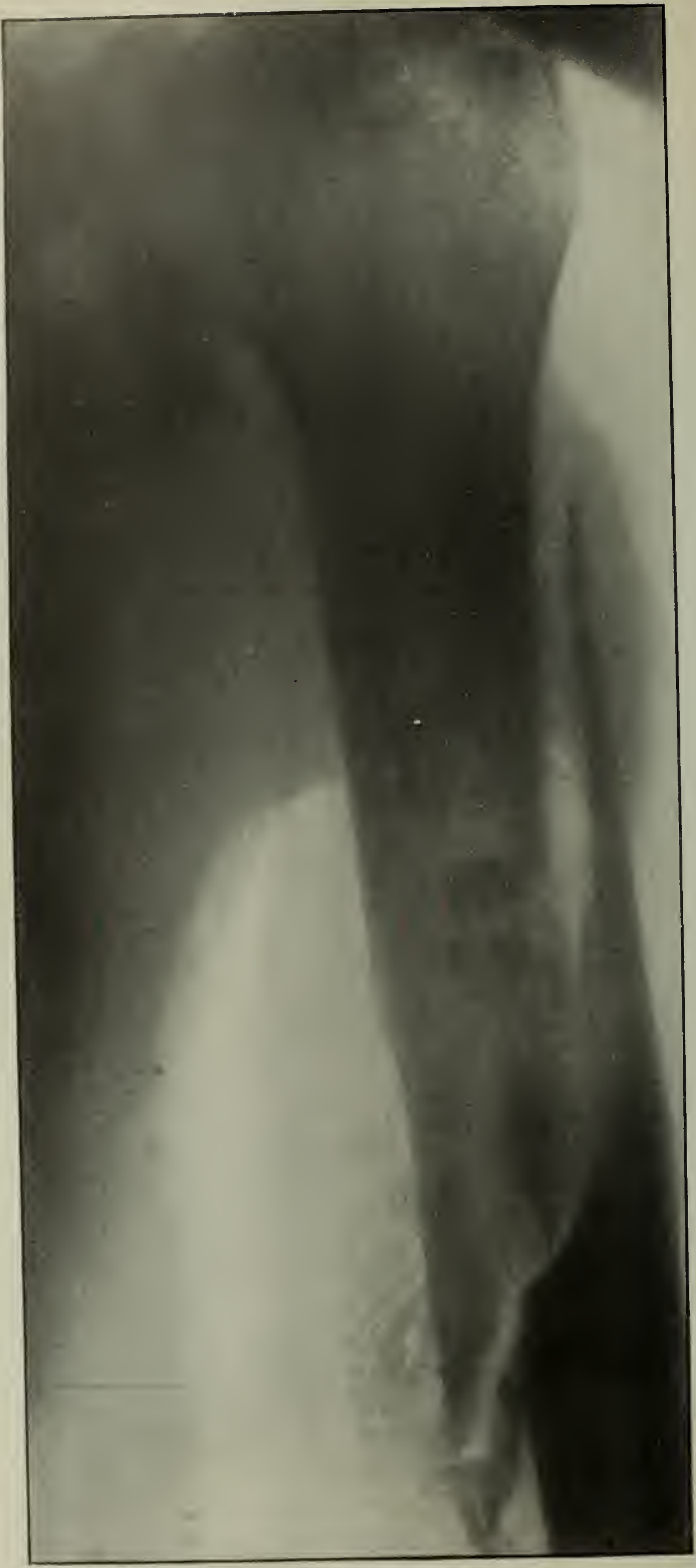
Gunshot Fracture of the Humerus.

The missile struck the bone and caused a long, splitting fracture, with some fragmentation of the proximal fragment.

The wound could have been caused by either a ricocheted rifle bullet or by a deformed shrapnel ball, either projectile being the low velocity of long range. These conditions are more common to shrapnel wounds, but the appearance of the larger metal fragment leads to the suspicion that it is a piece of the jacket of a rifle bullet.

The wound was not infected, and convalescence is well advanced, as is indicated by the callous formation.

Plate 88.



SHRAPNEL—PLATE 88.

UPPER EXTREMITY.

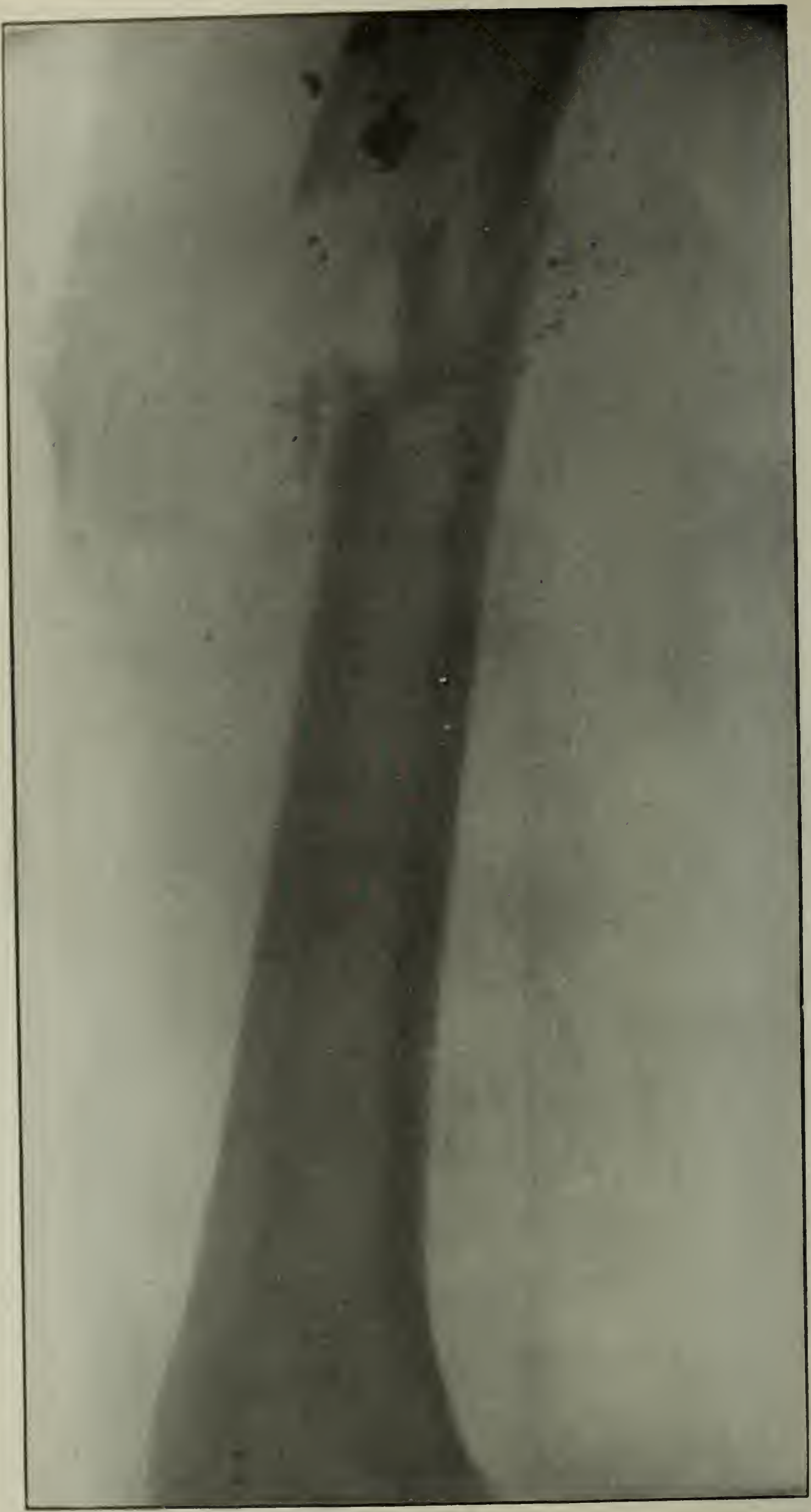
Gunshot Fracture of the Humerus, with Lodgment of the Missile.

The missile struck the shaft of the humerus from an anterior and external direction and caused a long diagonal splitting fracture with fragmentation, in which the bone absorbed all of the energy of the missile at the seat of fracture. The missile lies in the anterior surface of the humerus, in two fragments; the smaller, much less distinct, is seen about an inch above the larger.

The wound is not infected, and convalescence is well established, as is indicated by the callous formation, with overlapping of the fragments.

The treatment in such cases is conservative and the results are favorable.

Plate 89.



SHRAPNEL—PLATE 89.

UPPER EXTREMITY.

Gunshot Fracture of the Humerus.

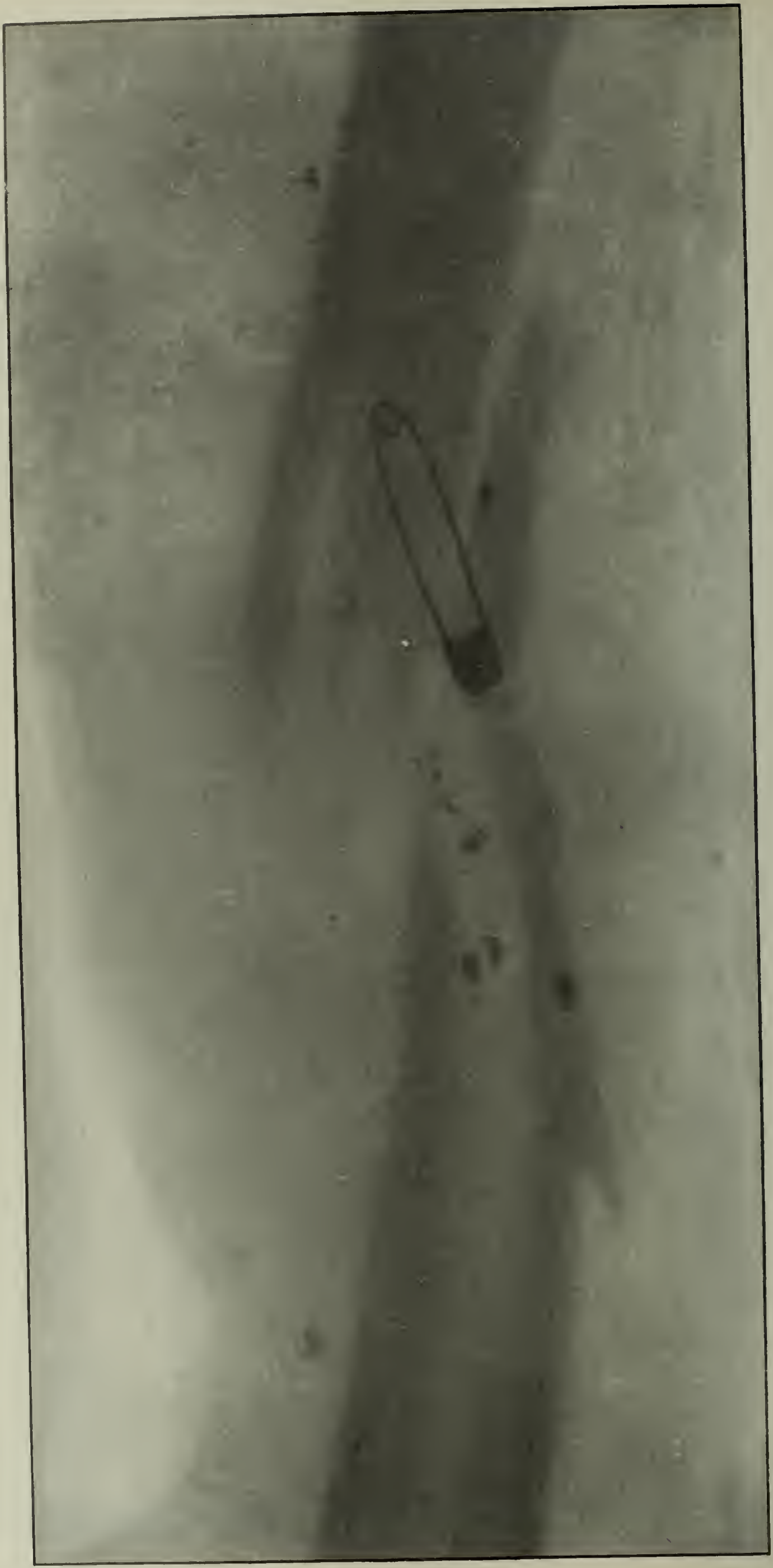
The course of the missile was from behind forward and outward. striking the bone on the posterior surface, causing a fracture with fragmentation, and lacerating the wound of exit with fragments of bones and with its own deformation.

The wound of exit is indicated in the plate.

The wound is infected.

Fragments of the missile lie on the posterior surface of the bone. as indicated by their dense shadow and distinct outline. The treatment in such cases is conservative and the results are favorable.

Plate 90.



SHRAPNEL—PLATE 90.

UPPER EXTREMITY.

Gunshot Fracture of the Left Humerus.

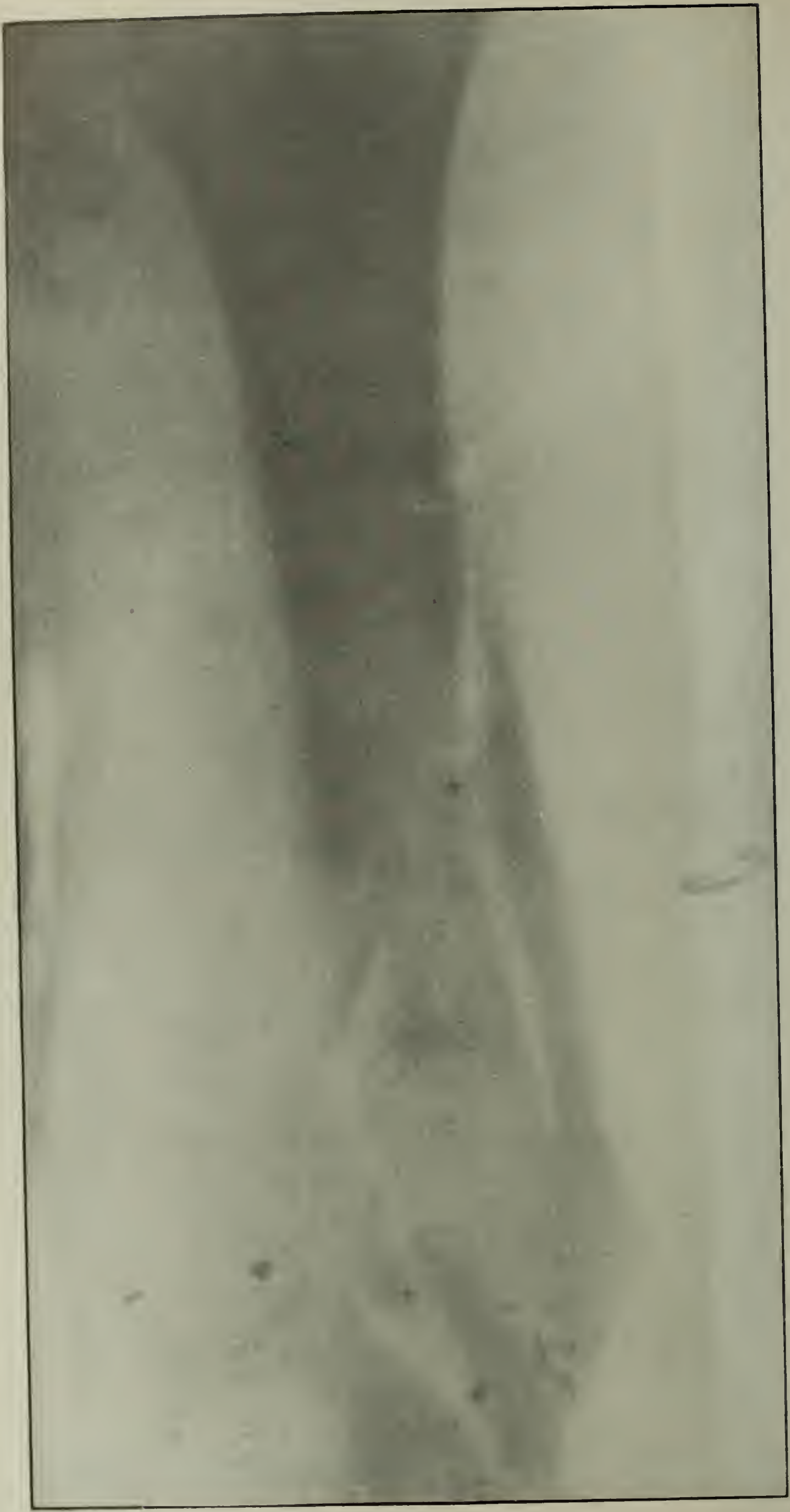
The course of the missile was transverse from without inward, with a transverse fracture and fragmentation.

This wound might have been caused by either a shrapnel ball or a deformed rifle bullet, but the distribution of the metallic fragments rather indicate the course of a shrapnel ball.

The metallic fragments lie farther from the plate than the safety pin of the dressing, which, therefore, lies behind the bone and the fragments of the missile lie in front.

The treatment in such cases is conservative and the results are favorable. The subsequent course may indicate interference for mal-union.

Plate 91.



SHRAPNEL—PLATE 91.

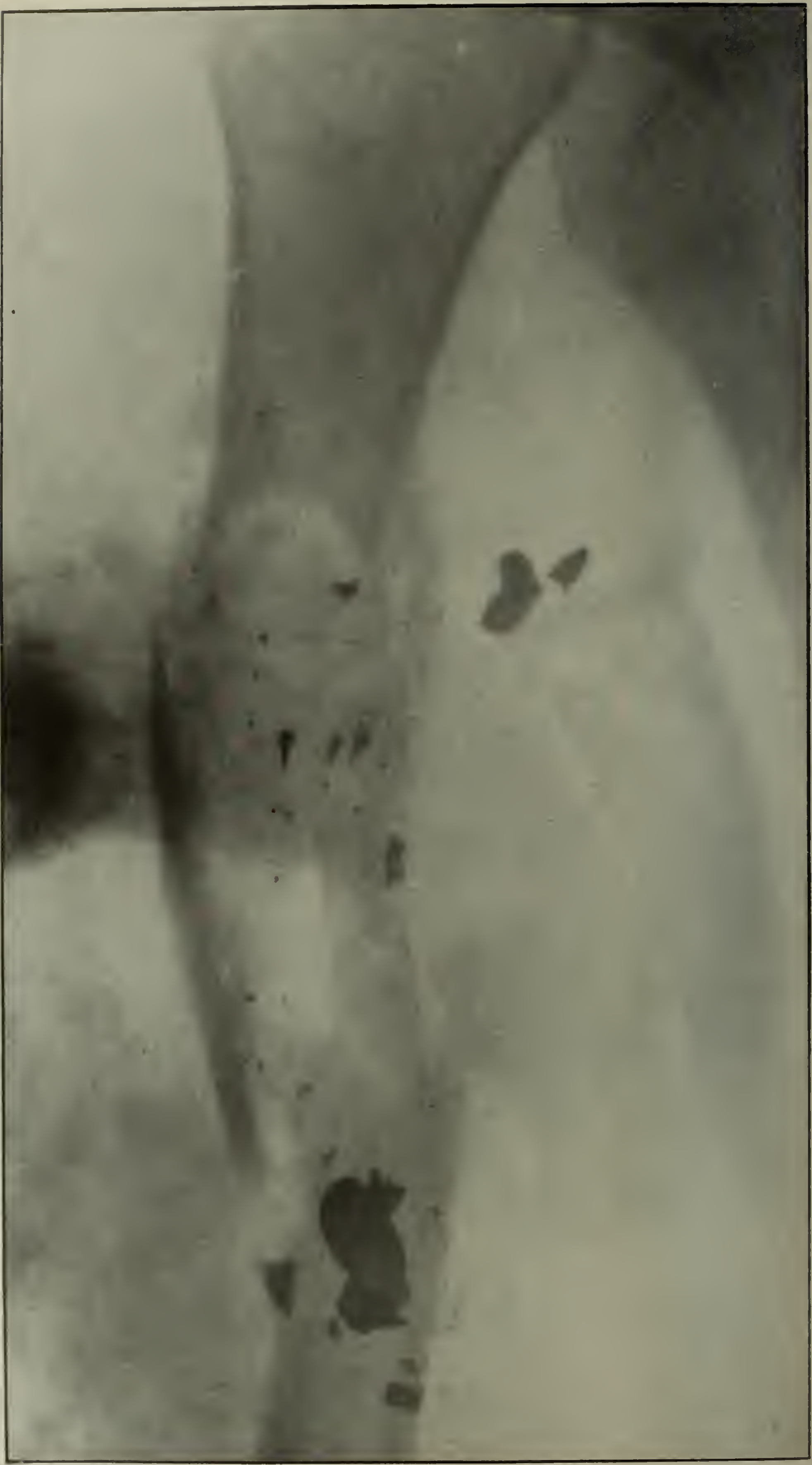
UPPER EXTREMITY.

Gunshot Fracture of the Left Humerus.

The course of the missile has been from without inward. The fragments of metal marking the path of the missile lie farther from the plate on the outer than on the inner side. This would indicate the former to be in front of the bone and the latter to be behind. The wound could have been caused by either a deformed rifle bullet or by a shrapnel ball, but the distribution of metallic fragments along the track of the missile rather indicates the agent to have been a shrapnel ball.

The case is similar in course and results to that shown in the preceding plate 90.

Plate 92.



SHRAPNEL—PLATE 92.

UPPER EXTREMITY.

Gunshot Fracture of the Right Humerus, with Lodgment of the Missile.

The missiles, shrapnel balls deformed by ricochet. were multiple. with a course from without inward and diagonally downward. The streaks of metal particles along the seat of fracture indicates the path of a shrapnel ball or fragment from the point of impact to the lower fragment of the fracture, where several deformed shrapnel fragments are lodged. Multiple wounds by shrapnel are common.

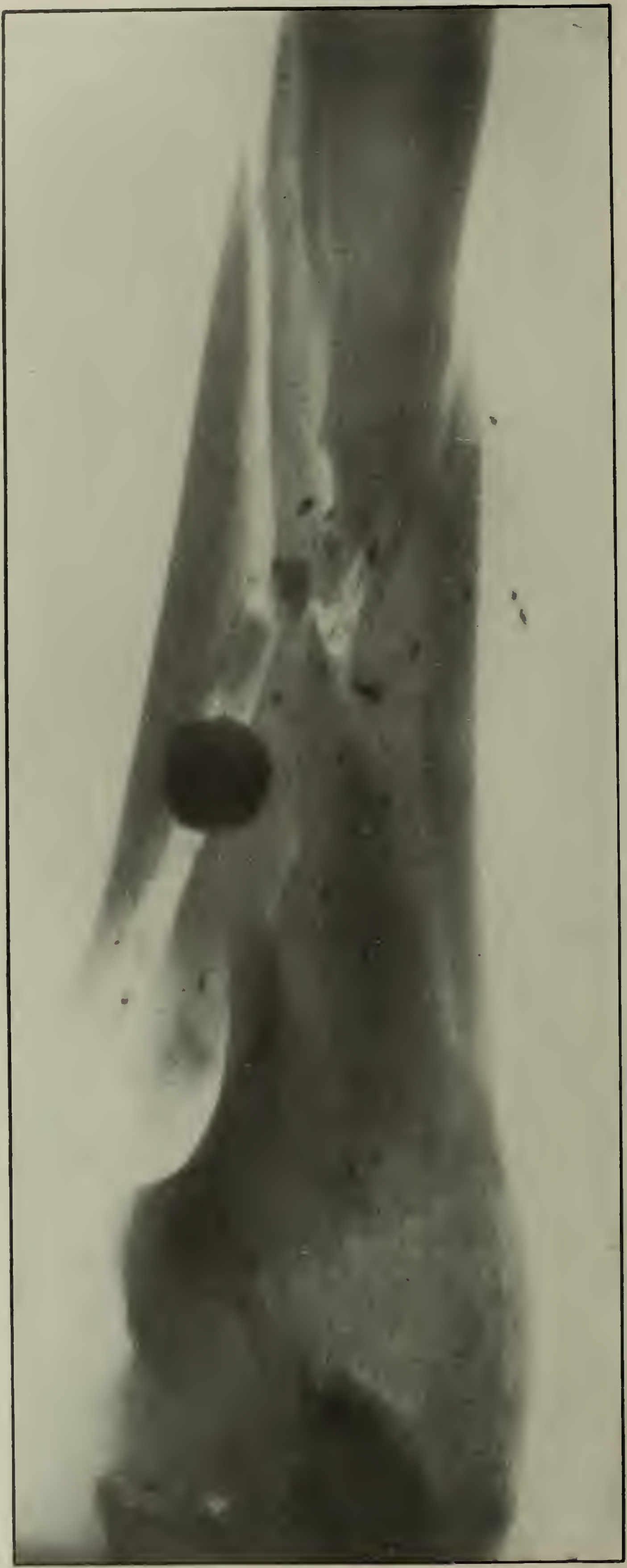
The wounds of entrance were small. There was no wound of exit. The wound was not infected. This is another evidence that does not defend the inference that ricocheted missiles are prone to introduce elements of infection into a wound.

The plaster dressing does not seem to meet the indications for support of the fracture.

The treatment is conservative in such cases.

Results are favorable.

Plate 93.



SHRAPNEL—PLATE 93.

UPPER EXTREMITY.

Gunshot Fracture of the Right Humerus.

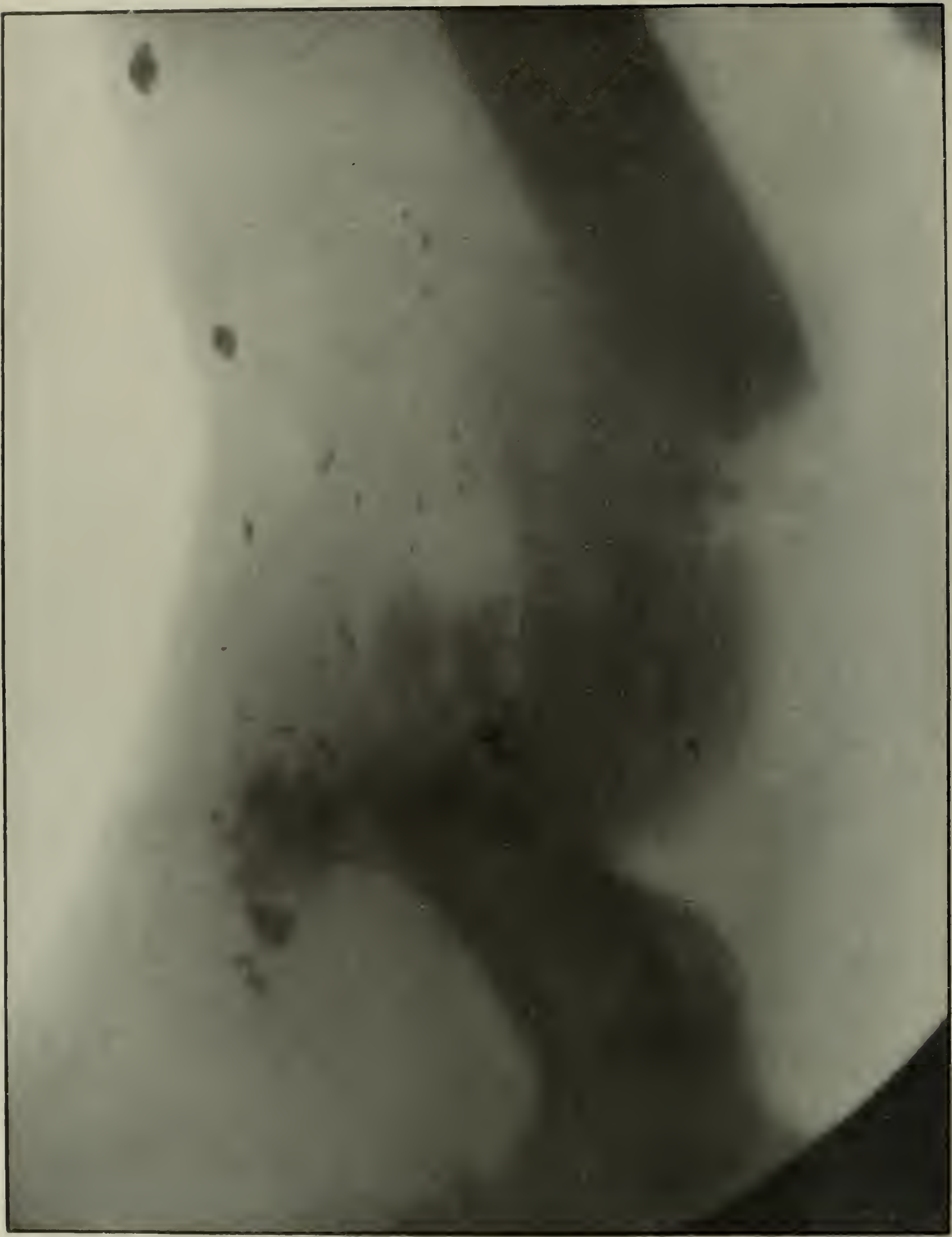
The course of the missile was transverse, from without inward and downward, striking the shaft of the bone squarely and producing a characteristic "butterfly" fracture, with a separation of the fragments.

The exposure was made with the ulnar side of the arm next to the plate, indicated by the clear outline of the internal condyle and the olecranon.

The nearly normal size of the shadow of the shrapnel ball shows it to be near the plate, and therefore to lie on the inside of the humerus. The irregular outline of the ball and the metallic fragments spattered about indicate that the ball was deformed by the detachment of fragments on direct impact with the bone. The wound is not infected.

The treatment is conservative in such cases and the results are good.

Plate 94.



Shrapnel—Plate 94.

UPPER EXTREMITY.

Gunshot Fracture of the Right Humerus.

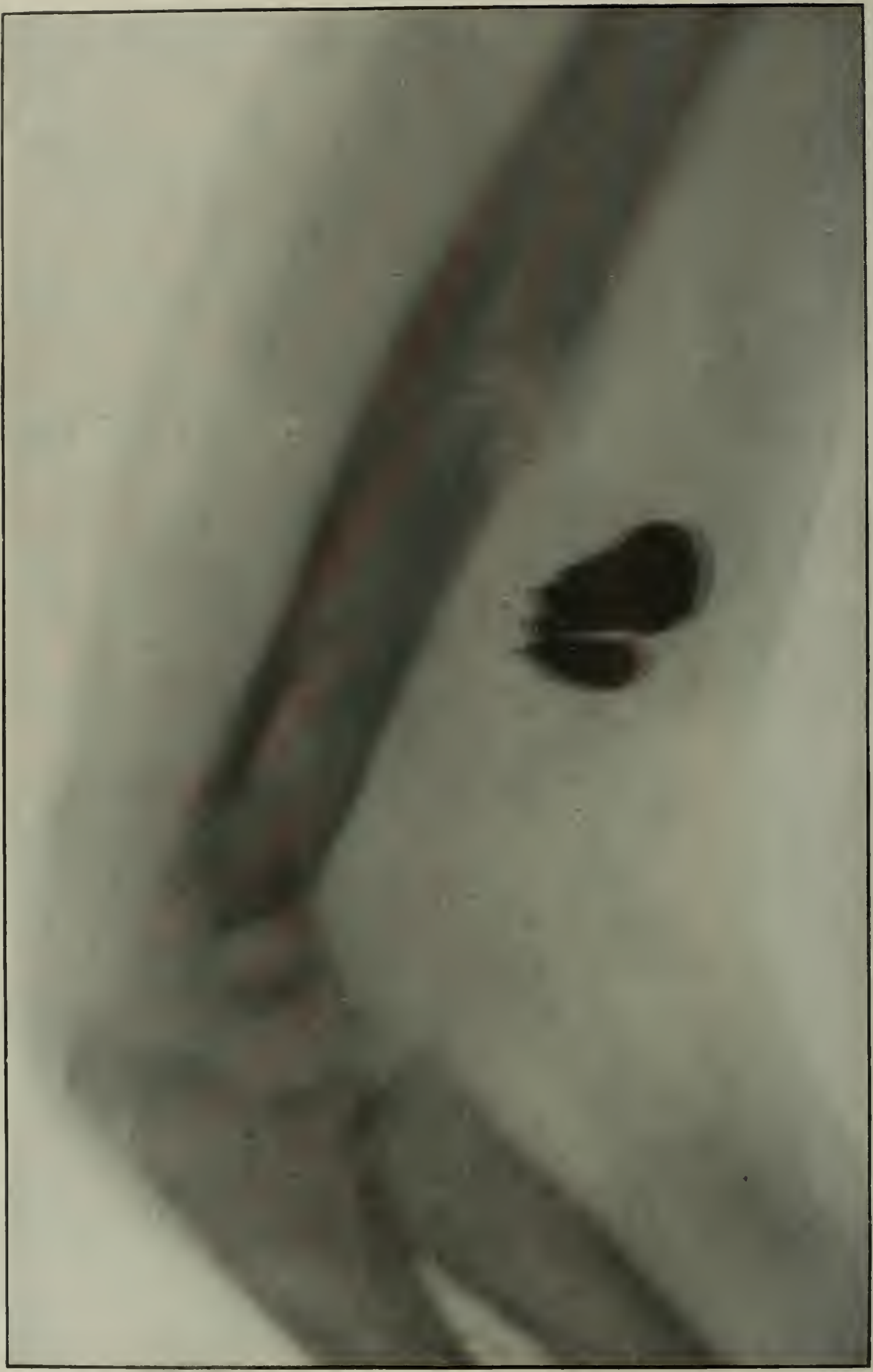
The course of the missile was from behind forward, causing a transverse fracture of the humerus with some fragmentation.

The wound is in a state of established convalescence, with considerable separation of the ends of the large fragments and without infection, shown by the formation of callus and by an attempt at union in faulty position.

The trail of the metallic fragments of the missile from behind forward and their location near the anterior surface of the arm indicate the course of the missile, either a rifle bullet or a shrapnel ball—most probably the latter, as the lead core of the rifle ball, protected by the jacket, does not break up into as many small particles as does the shrapnel ball. The missile was deformed by ricochet before striking the bone.

The early treatment in such cases is conservative, although the subsequent course may indicate interference for malposition. The results are favorable.

Plate 95.



SHRAPNEL—PLATE 95.

UPPER EXTREMITY.

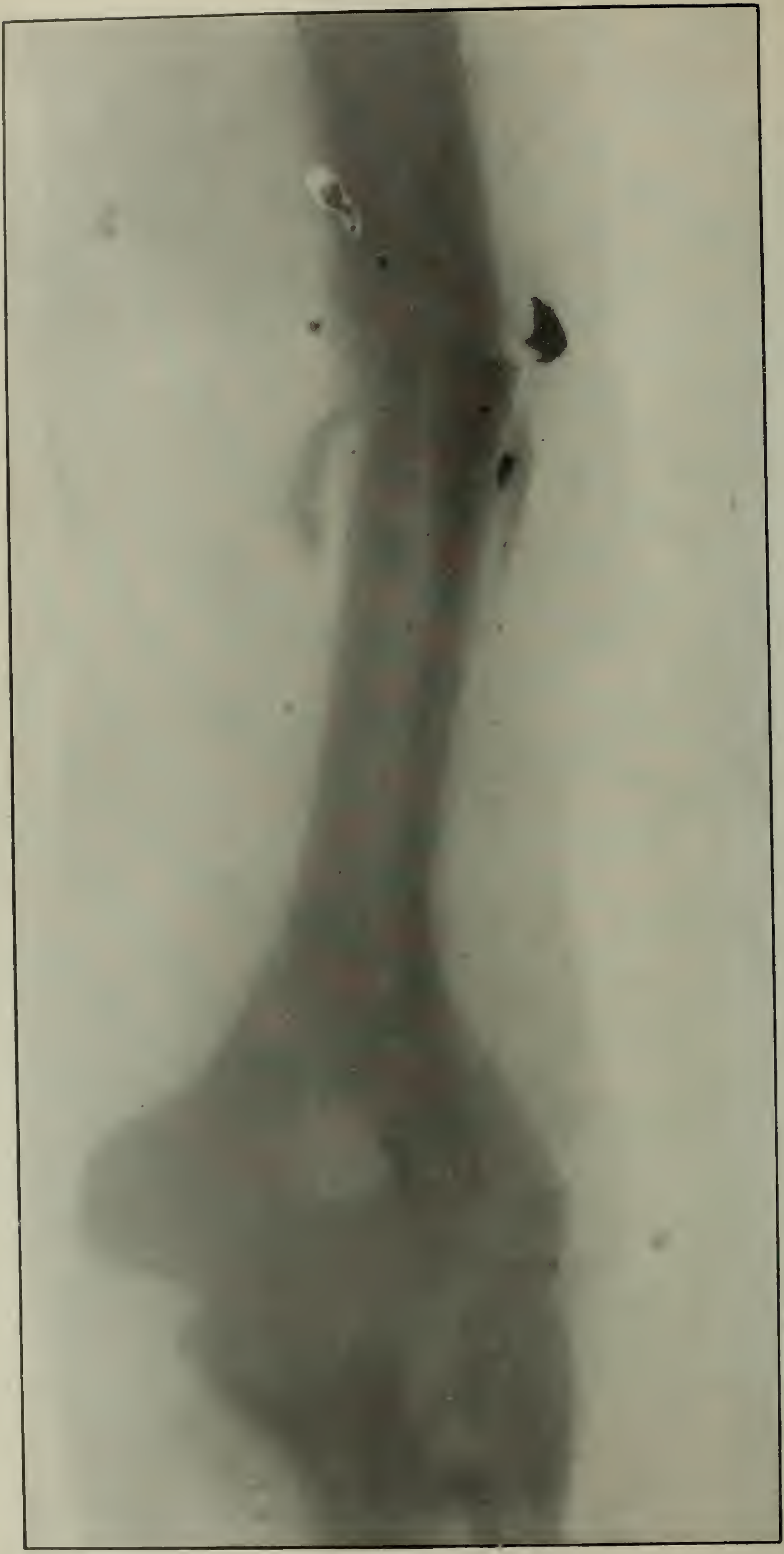
Gunshot Wound of the Humerus, with Lodgment of the Missile.

The course of the missile was from before backward. The missile consisted of two large fragments of a richocheted shrapnel ball, almost spent in energy before striking the arm, as its penetration was just enough to pass through the soft parts and strike the humerus, causing a fissure without separation of fragments. The wound was clean.

The treatment in such cases is naturally conservative.

[The epiphysis of the olecranon being so distinct and showing no fusion, indicates the youth of this soldier, whose age could not have been more than 16 years.]

Plate 96.



RIFLE—PLATE 96.

UPPER EXTREMITY.

(a) Gunshot Fracture of the Left Humerus—(b) Gunshot Fracture of the Left Elbow.

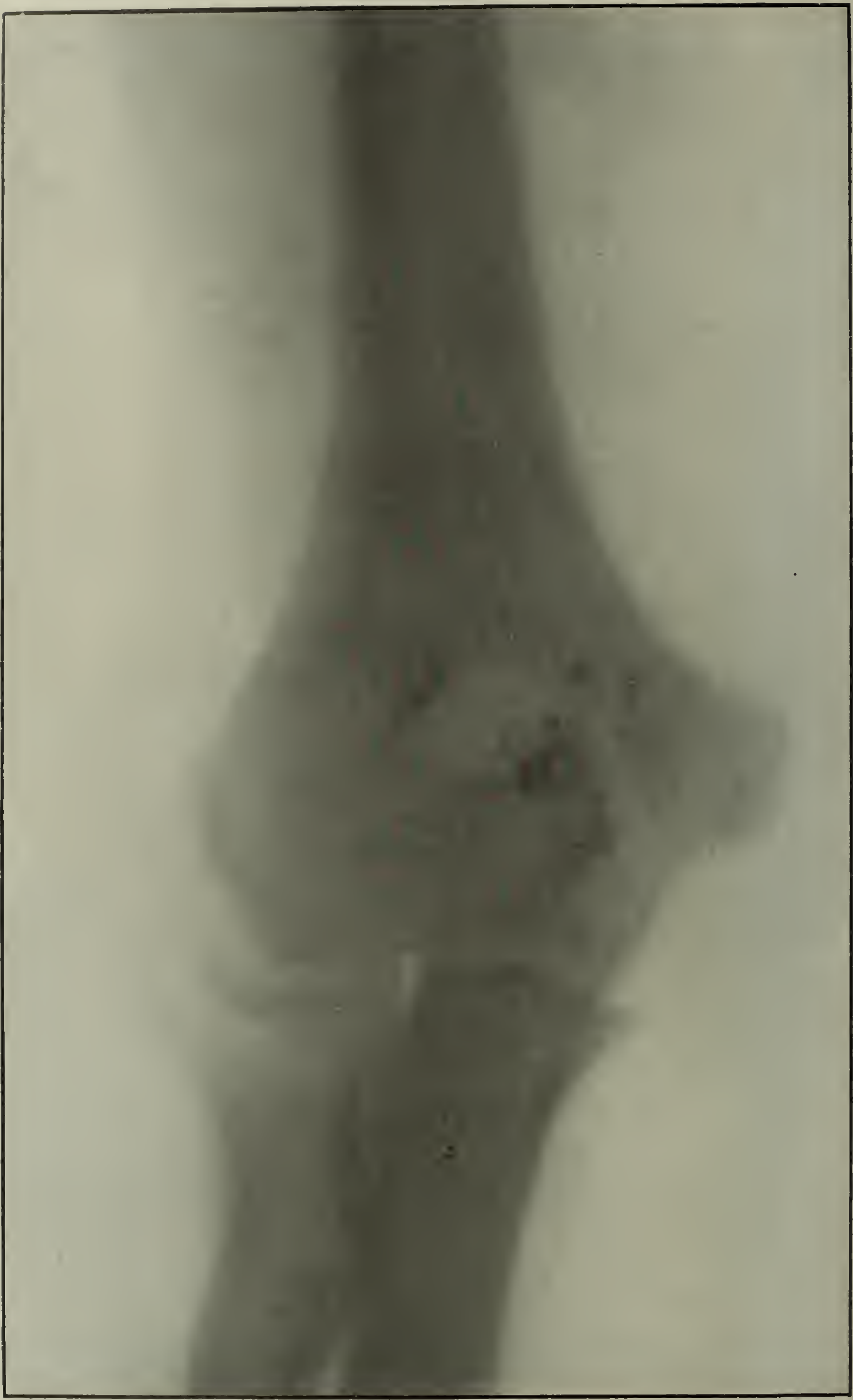
The missile was a rifle bullet with the reduced velocity of long range, passing transversely along the articulations of the elbow, fragmenting the radius and ulna and fissuring the humerus through both condyles.

The emergency treatment is antiseptic dressing and immobilization, with prompt transportation to the base.

Subsequent treatment is conservative, with proper immobilization.

Results as to limb are favorable, with probable loss of function of the elbow.

Plate 97.



SHRAPNEL—PLATE 97.

UPPER EXTREMITY.

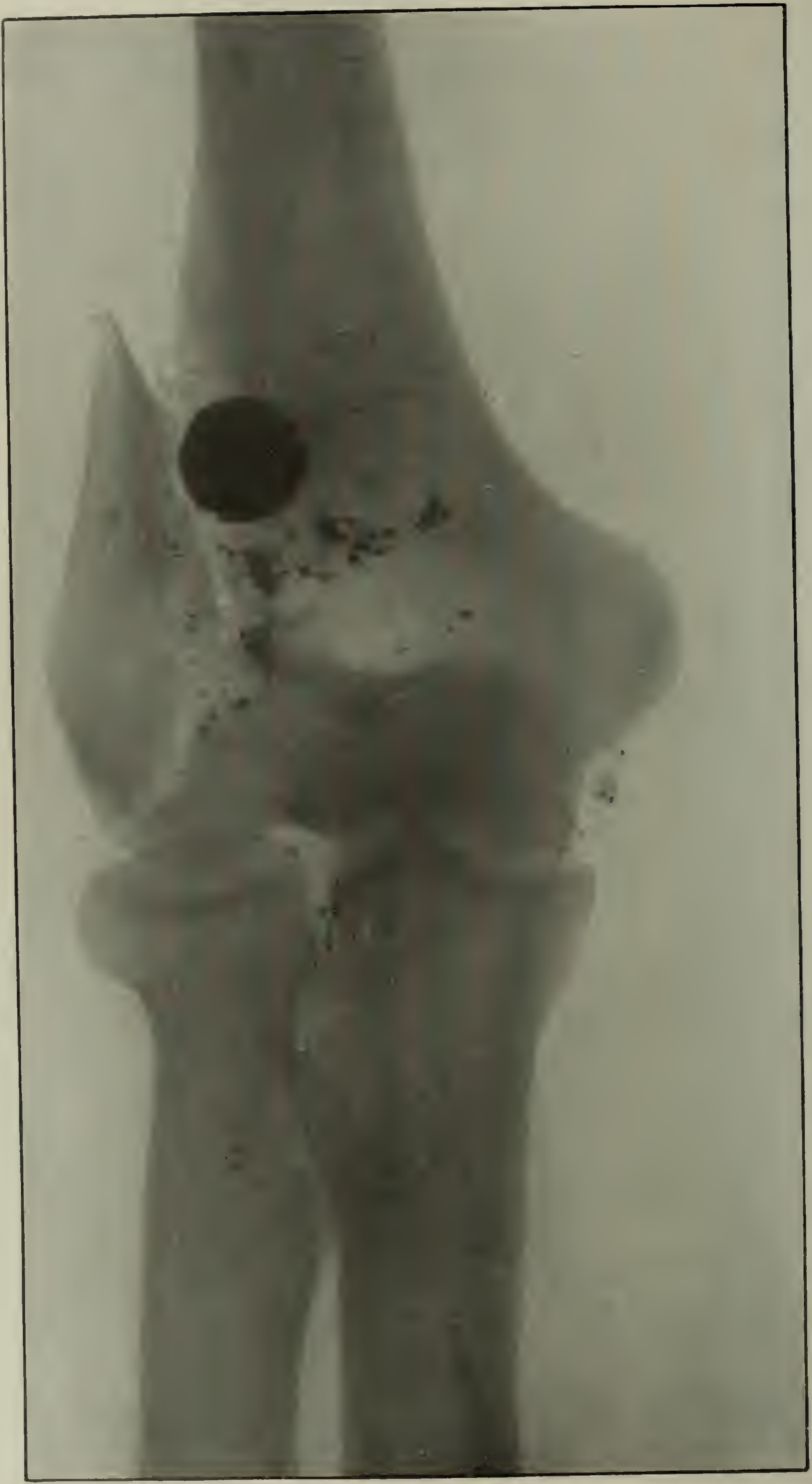
Gunshot Wound of the Right Elbow.

The course of the missile was superficial, downward and outward from above the internal condyle of the right humerus to the wound of exit over the internal border of the ulna. Metal fragments of the missile have lodged against the tip of the olecranum, with no fracture and with no damage to the joint. The low velocity of the missile, producing so slight a bone injury and the track of lead particles along the line of contact with the bones determines it to have been a shrapnel ball.

The wound was not infected.

The treatment in such cases is naturally conservative and the results are very favorable.

Plate 98.



SHRAPNEL—PLATE 98.

UPPER EXTREMITY.

Gunshot Fracture of the Right Elbow, with Lodgment of the Missile.

The course of the ball was from before backward, striking the lower end of the humerus squarely above and internal to the external condyle and splitting off the condyles with a line of fracture extending through the capitellum, without much separation of the fragment.

As the impact was direct, the energy producing such effect was that of low velocity.

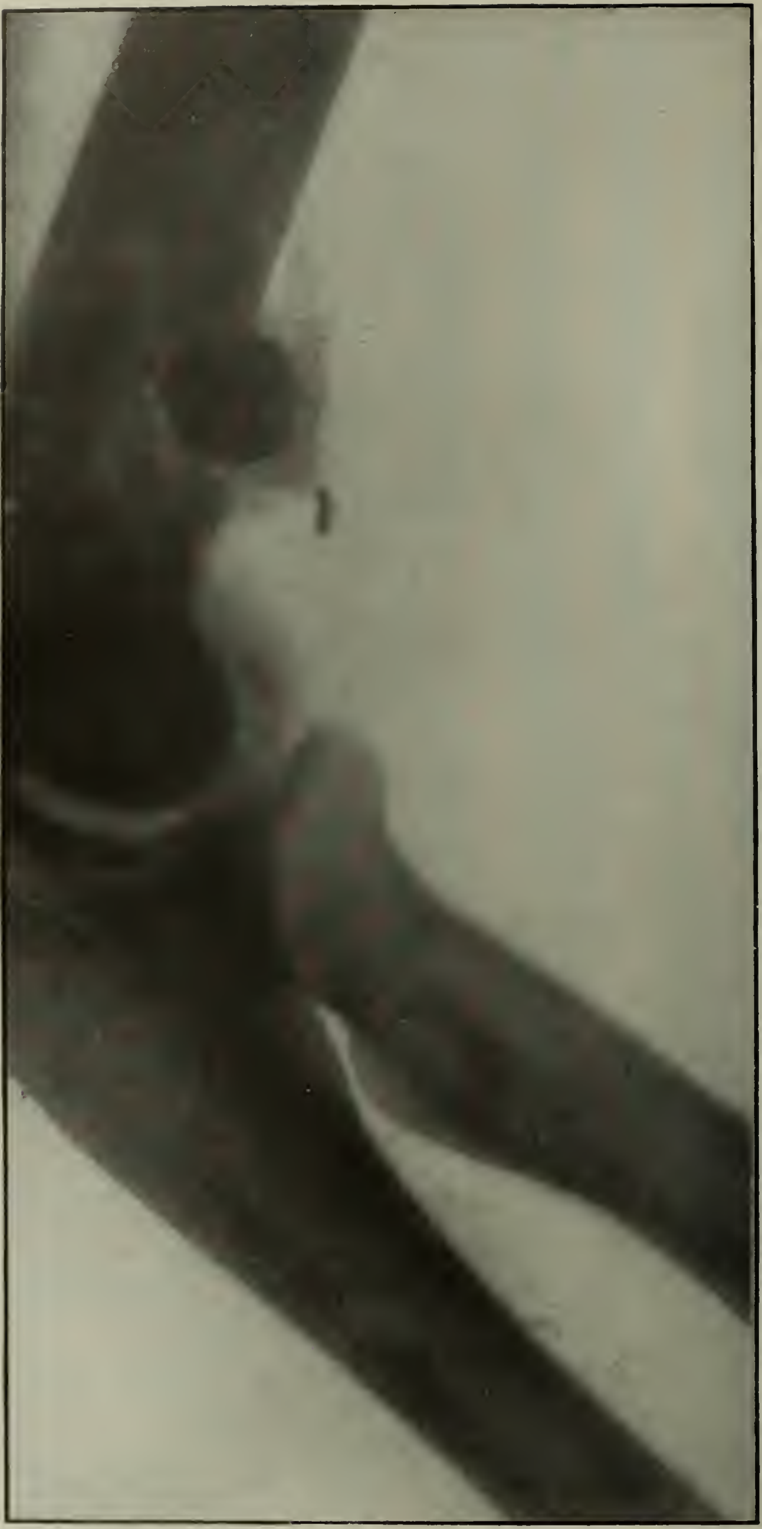
The great radiographic penetration shown in this plate gives the shadows of the ball great distinctness and definite outline, especially in the line of fracture, although its opposite border is not in such sharp contrast. This appearance, together with the very slight enlargement, leads to the suspicion that the ball lies posteriorly, but a larger metal fragment, below the ball, is less clear and suggests a position anterior to the bone. With the posterior surface of the arm next to the plate and with but little difference in the distance from the plate to either the anterior or posterior surface of the bone, it is not easy to determine the location of the ball in the anteroposterior direction, but it would seem to be on the anterior surface of the bone.

The wound is not infected. The treatment is conservative and results favorable.

The subsequent course would probably indicate the removal of a foreign body from a site so near the joint.

C.

Plate 99.



SHRAPNEL—PLATE 99.

UPPER EXTREMITY.

Gunshot Fracture of the Right Elbow, with Lodgment of the Missile.

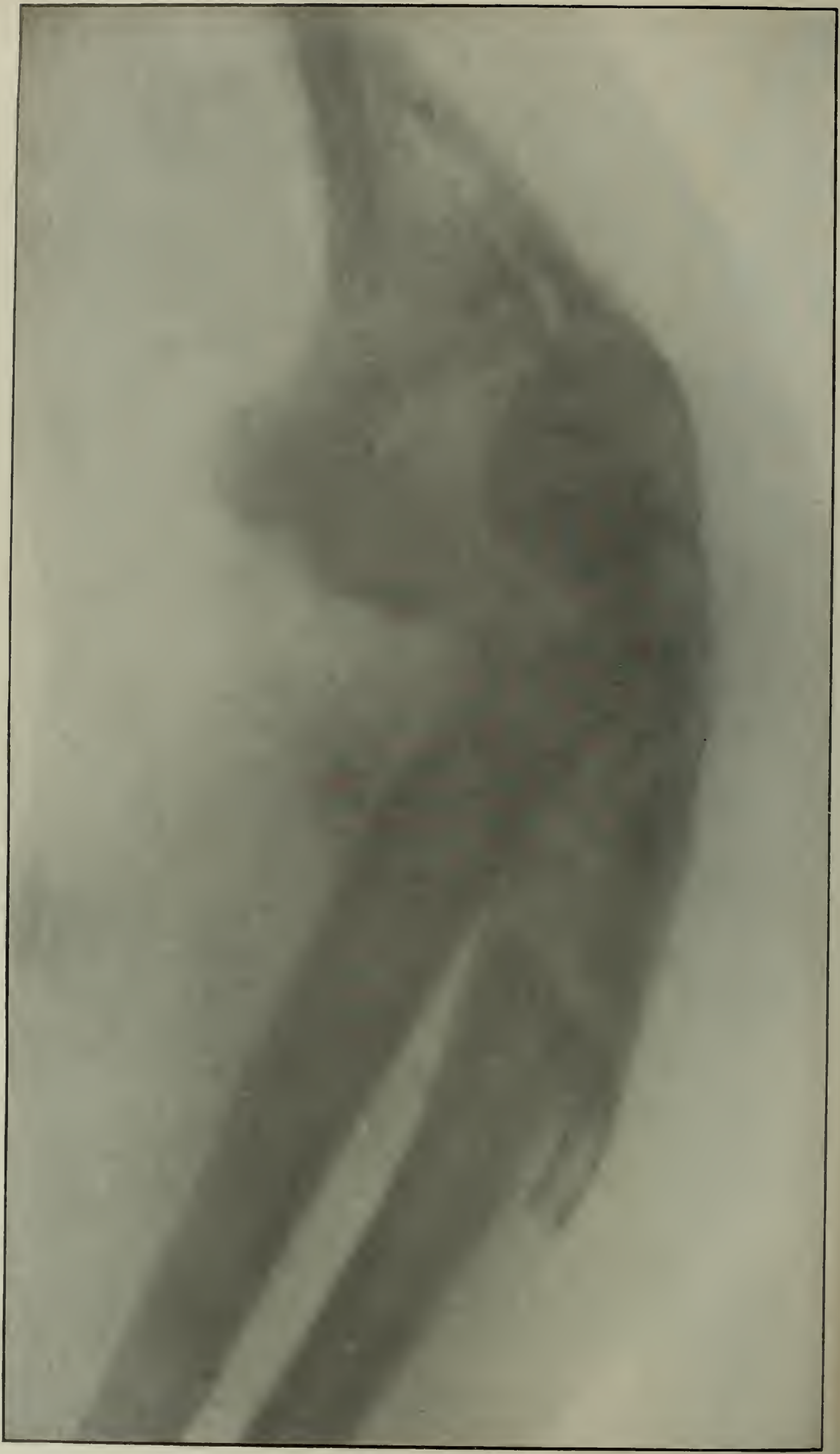
Same wound as in plate 98.

The sharp border of the greater sigmoid cavity and the head of the radius fully obscured by the coracoid process indicate, that in this exposure, the ulnar side of the arm was next to the plate.

With this condition and the enlarged shadow of the ball, the latter must lie a little distance away from the plate, and, actually, on the radial side of the humerus.

The position of the ball in the anteroposterior line is manifest, and its position confirms the deductions made therefrom in the preceding plate (98).

Plate 100.



SHRAPNEL—PLATE 100.

UPPER EXTREMITY.

Gunshot Fracture of the Elbow.

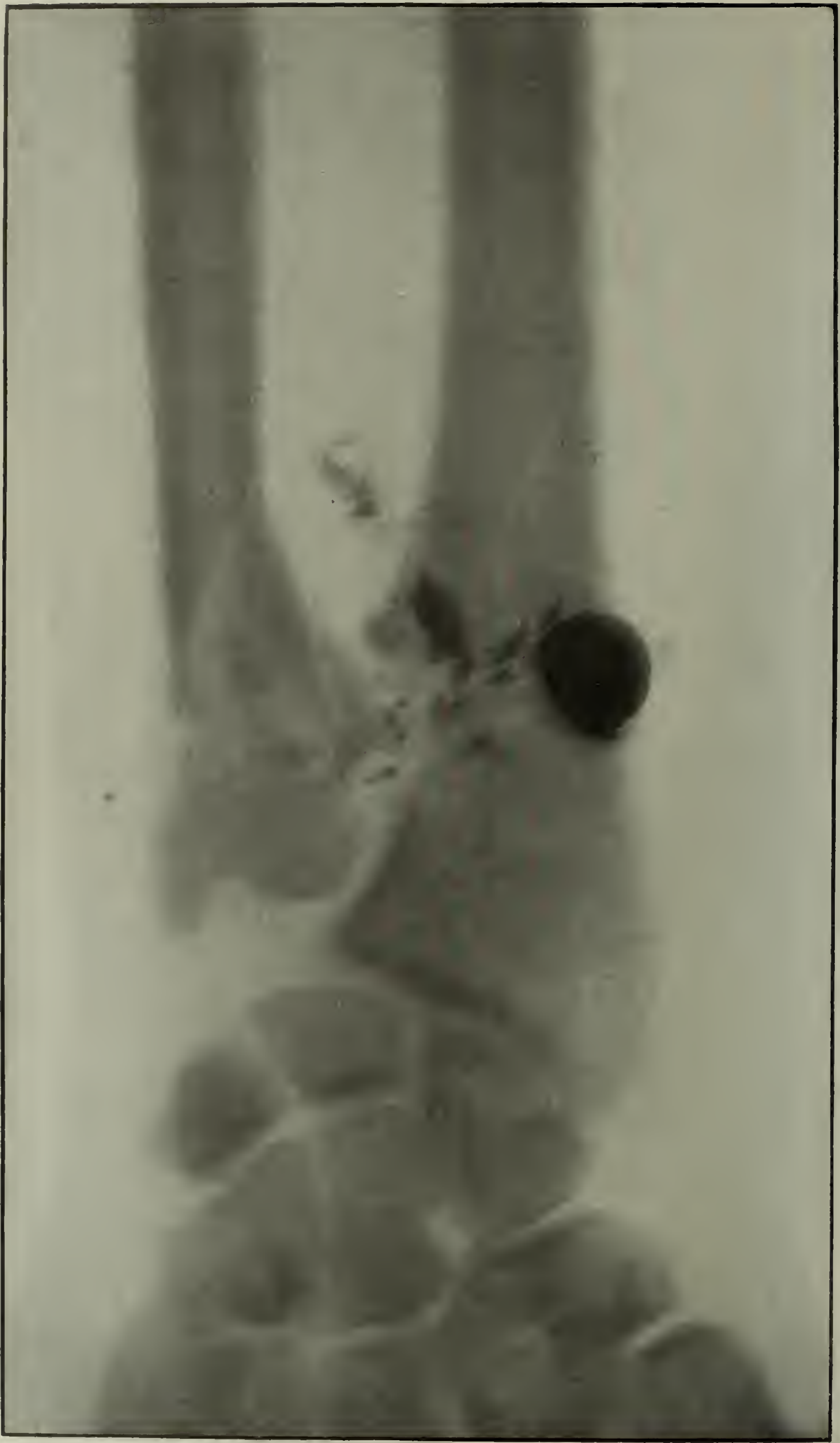
The primary condition of this wound is not manifest from the appearance of the plate, which reveals only a destruction of the joint by fracture and an advanced stage of infection, involving the fragments and lower end of the shaft of the humerus, as indicated by the rarefaction of these parts.

Several fragments of the missile are in evidence; it is probable that others have escaped with drainage.

Drainage tubes are seen in the lower arm and upper forearm. The primary conservative treatment has been continued through two or three months.

The case is from Gulhané Military Hospital, where the scientific character of surgical service already referred to must lead to the inference that all the surgical indications have been met in the management of the case.

Plate 101.



SHRAPNEL—PLATE 101.

UPPER EXTREMITY.

Gunshot Fracture of the Left Radius and Ulna, with Lodgment of the Missile.

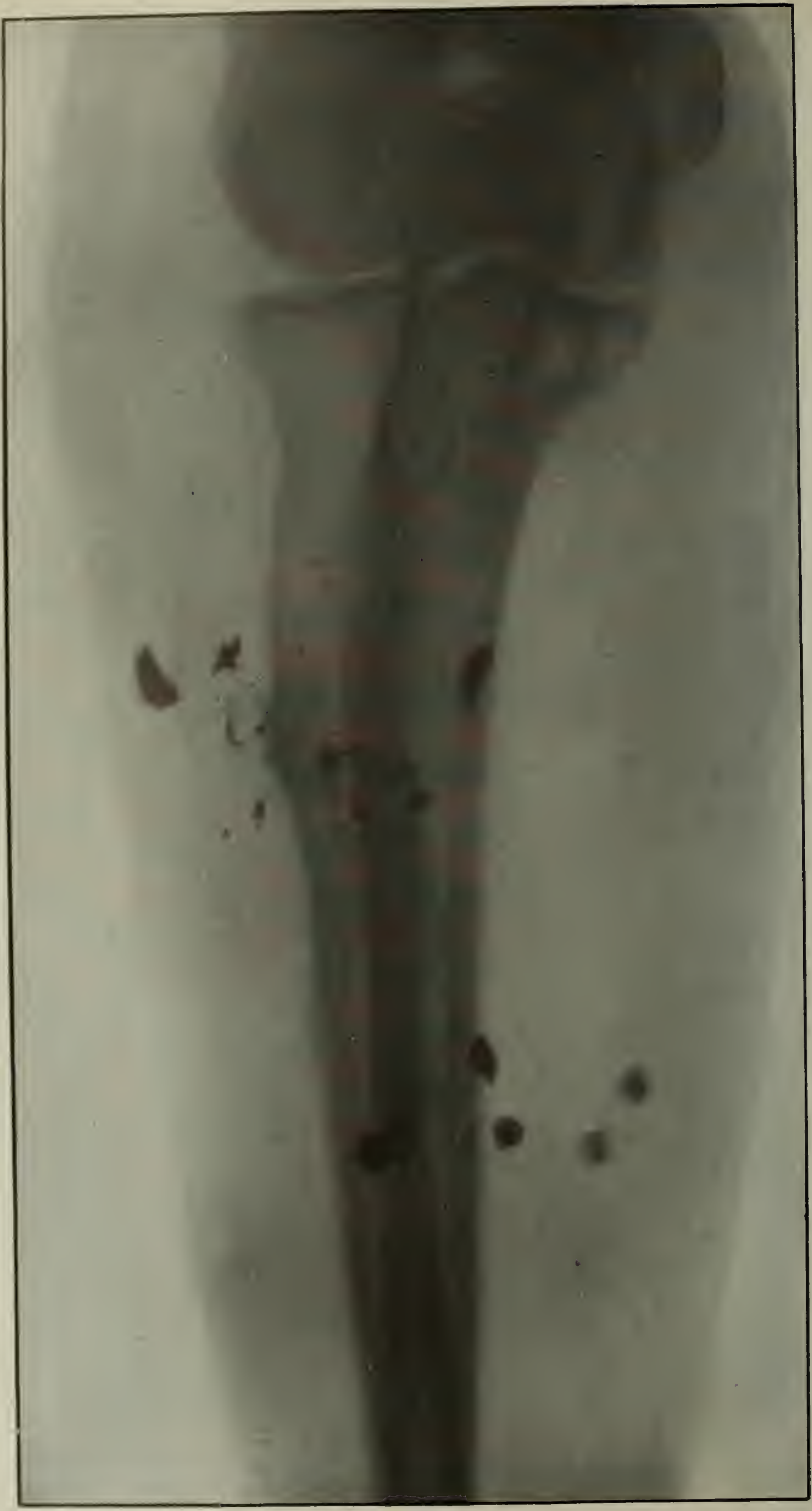
The course of the missile was from within outward, striking the ulna a glancing blow just above the styloid process, fracturing the anterior surface, and then striking the internal border of the radius and causing a slight notching fracture with a longitudinal fissure.

The forearm lies in supination, with its posterior surface next to the plate. As the outline of the missile, as well as of the bone, is blurred, there is not enough differentiation in the shadows to indicate the anterior or posterior location of the missile with reference to the radius.

The shrapnel ball struck the bone with low velocity, as all of its remaining energy, absorbed by the two small bones, caused little damage and practically no displacement of fragments. The wound was not infected.

The treatment in such cases is, of course, conservative.

Results are uniformly good.



Shrapnel—Plate 102.

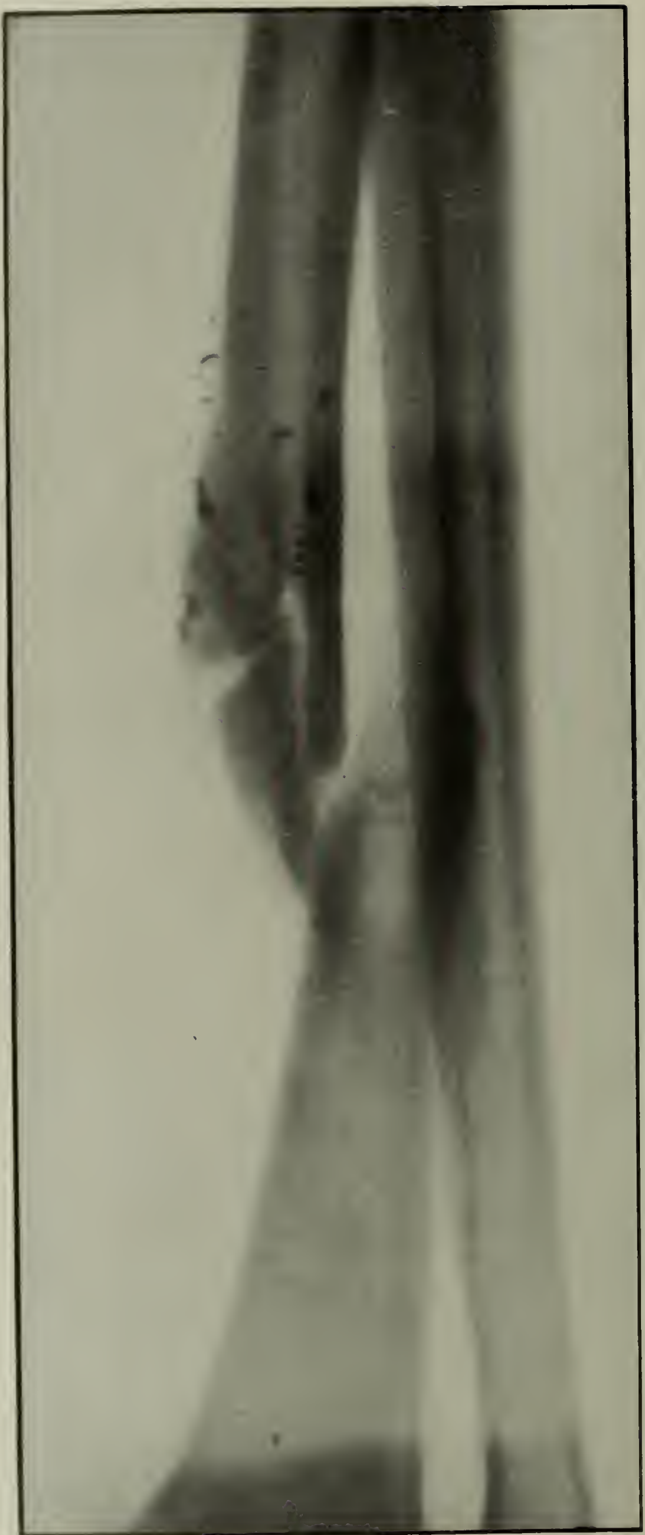
UPPER EXTREMITY.

Gunshot Fracture of the Right Radius.

A fragmented shrapnel ball, coursing from without inward, struck the upper third of the shaft of the radius and caused a greenstick fracture. A fragment of the ball, larger than those seen in the plate, inflicted the greater damage and escaped through the wound of exit, to be seen below the large fragment on the left of the plate.

The olecranon process of the right ulna rests on the photographic plate, with the forearm in semipronation, so that the shadow of the radius falls nearly in line with that of the ulna. With the forearm restored to the anatomical position, the spattered metallic fragments, now seen lying over and to the left of the radius, would then be shown lying on the outer border of and posterior to the radius, except for the upper right metallic fragment, now lying over the ulna, which would be seen lying over the anterior surface of the radius. The six pellets seen in the lower forearm have not contributed to the injury of the bone. Their density and indefinite outline indicate a position in the forearm opposite to the side next to the plate. With the forearm in supination they would appear in their real position, in front of the ulna and on the outside of the radius.

Plate 103.



SHRAPNEL—PLATE 103.

UPPER EXTREMITY.

Gunshot Fracture of the Right Radius.

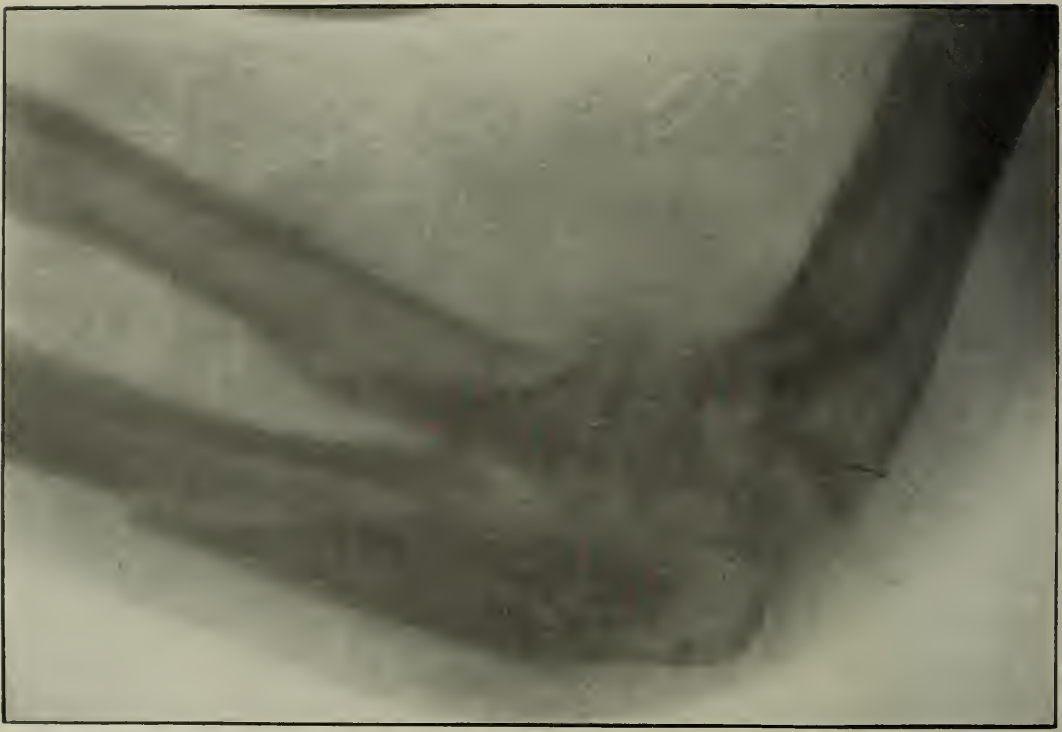
The missile in its course from behind forward and from above downward left a trail of its metal particles along the line of its first contact until the bone yielded to the pressure in a transverse fracture.

The arm lies in slight pronation with the longitudinal ridges of the dorsal surface of the ulna, shown distinctly next to the photographic plate. The upper end of the lower radial fragment, shown as overlying the ulna, is inclined forward in the anatomical position. The metal particles are on the outer and posterior border of the radius.

The treatment in such cases is conservative.

Results as to function are uncertain.

Plate 104.



SHRAPNEL.—PLATE 104.

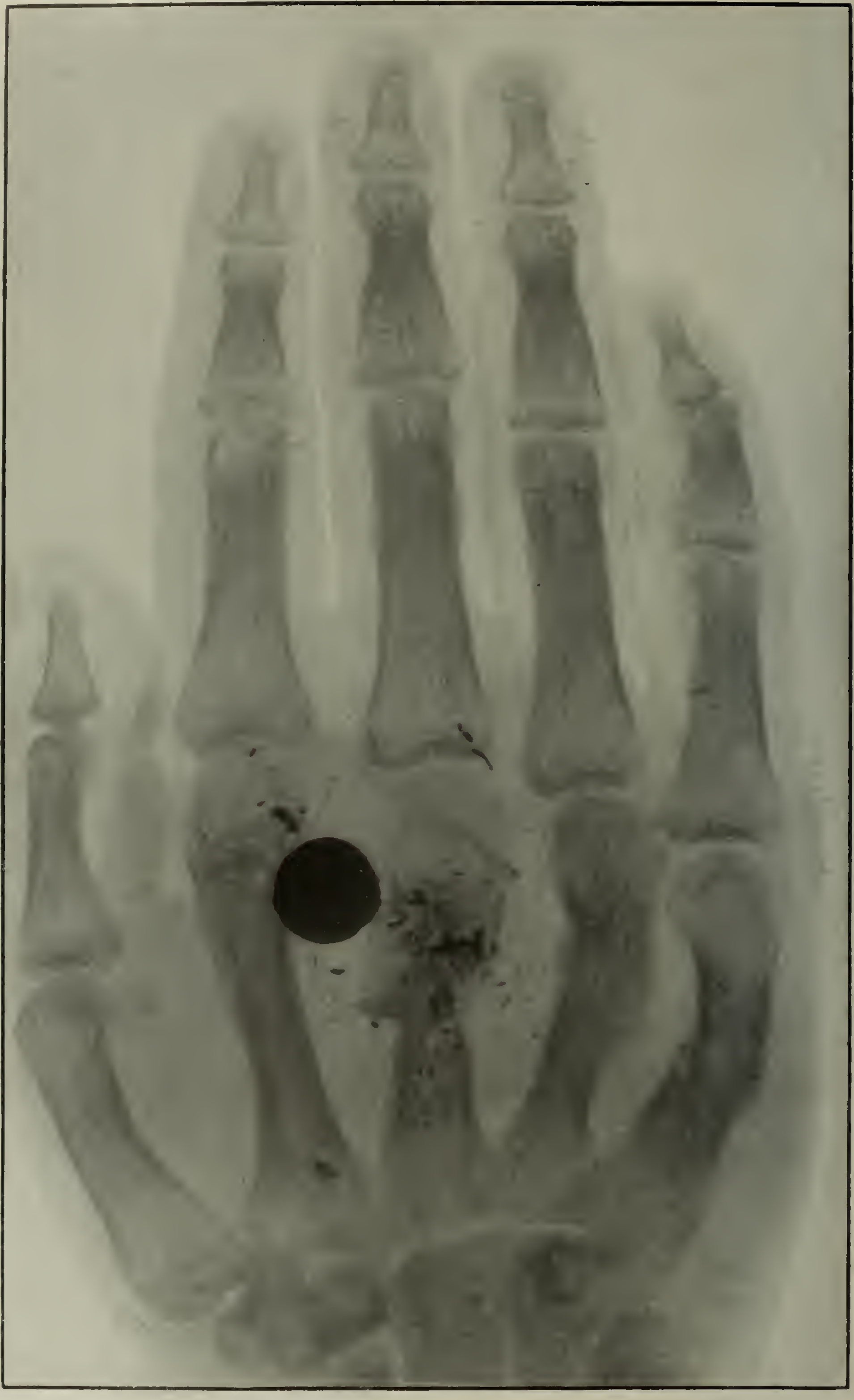
UPPER EXTREMITY.

Gunshot Fracture of the Ulna.

The course of the missile was tangential along side of the upper end of the ulna and internal condyle of the humerus, with a splitting effect on the ulna, which formed three fragments by breaking off the olecranon, and one lateral fragment from the shaft of the bone without displacement. The line of metallic particles shows the path of the ball in its slight contact with the bones, beginning on the side of the ulna and extending along the side of the internal condyle from where the ball escaped through the skin. The wound, not infected, was treated as simple fracture. A few fine lines on the plate above the fracture are due to scratches on the negative.

Results in such cases should be good.

Plate 105.



SHRAPNEL—PLATE 105.

UPPER EXTREMITY.

Gunshot Fracture of the Right Metacarpus.

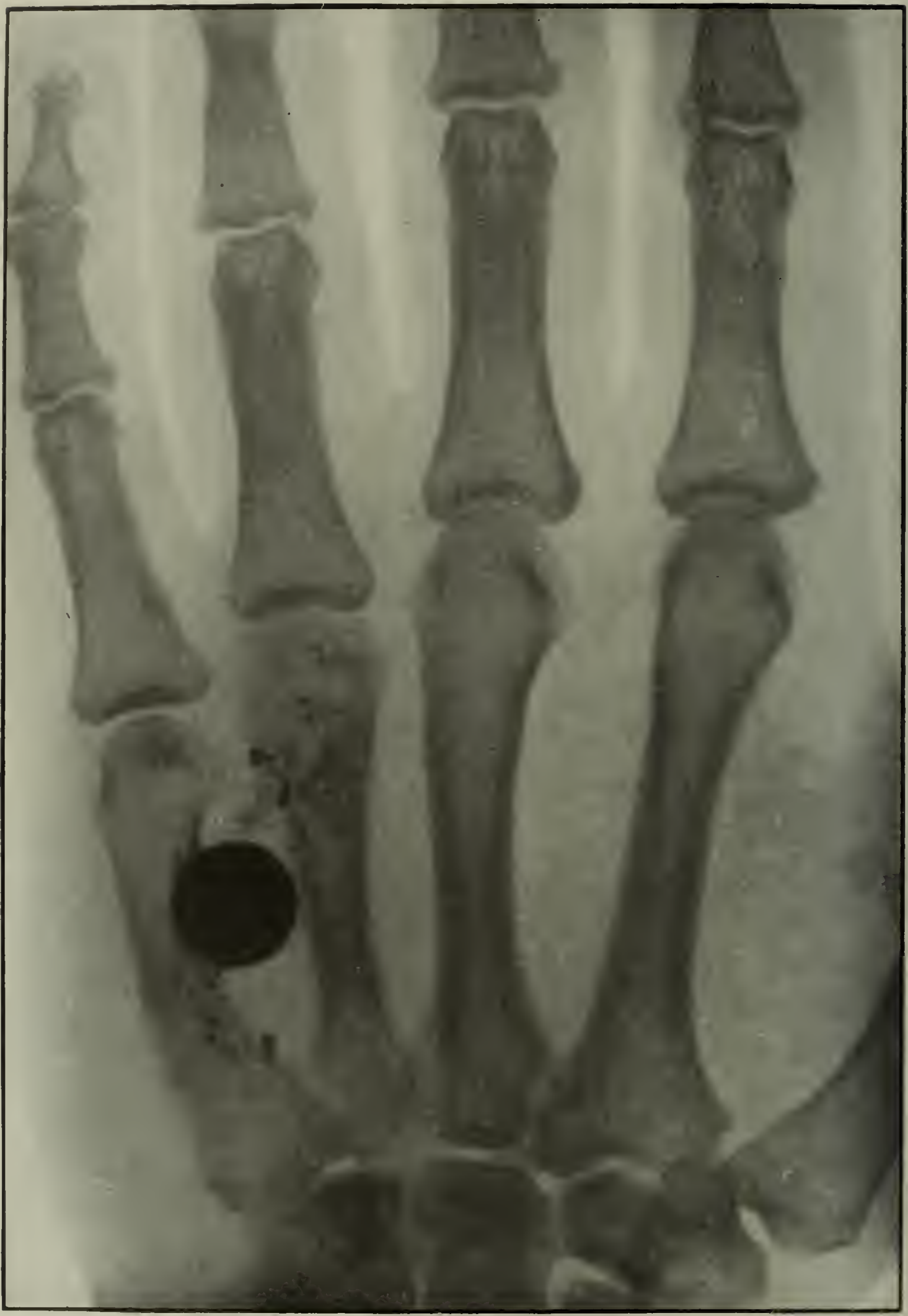
The course of the missile was from the outer border of the hypothnear eminence diagonally downward through the palm, lodging against the second metacarpal bone with fracture of last four metacarpals.

The metal particles are not seen on the fourth and fifth metacarpals because the violence at these points was transmitted through soft parts, but the projectile spent its remaining energy directly against the second and third metacarpals.

The palm of the hand was next to the photographic plate, as indicated by the immediate contact of the thumb. The shadow of the bones is not dense, but in deep contrast with the shadows of the ball and metal fragments, which are so clearly outlined with the ball of normal size that the ball is thus shown to lie on the palmar side of the hand.

The treatment is conservative, with judicious interference when opportunity shall offer for removal of the missile.

Plate 106.



SHRAPNEL—PLATE 106.

UPPER EXTREMITY.

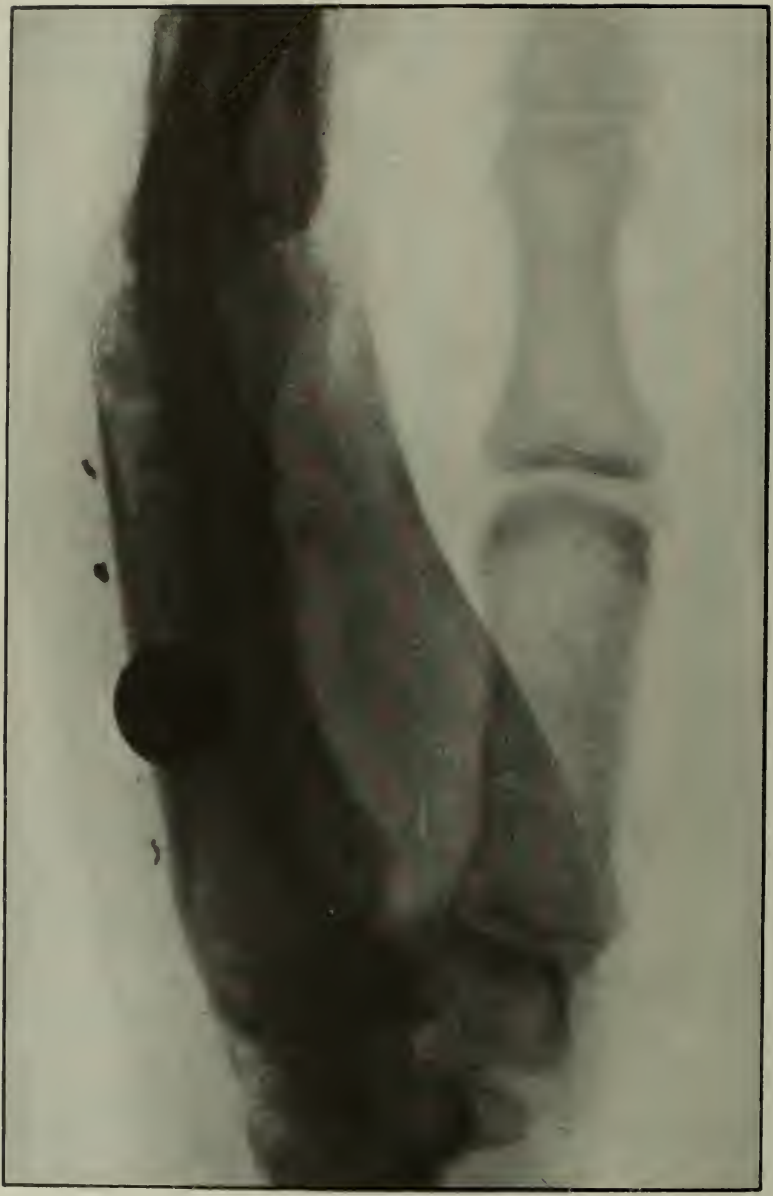
Gunshot Fracture of the Left Metacarpus, with Lodgment of the Missile.

The palm of the hand lies next to the plate. The ball is very slightly enlarged and the small metal fragments are indistinct, indicating that they and the ball lie on the back of the hand.

The ball struck the third knuckle and lodged beneath the skin between the fourth and fifth metacarpals, fracturing both bones without displacement of fragments. In the recent wound the condition would be apparent, but after days of inflammatory reaction and infection, the swelling is too great to make any determination by palpation.

The treatment is removal of the missile. Good results regularly follow.

Plate 107.



SHRAPNEL—PLATE 107.

UPPER EXTREMITY.

Gunshot Fracture of the Left Metacarpus, with Lodgment of the Missile.

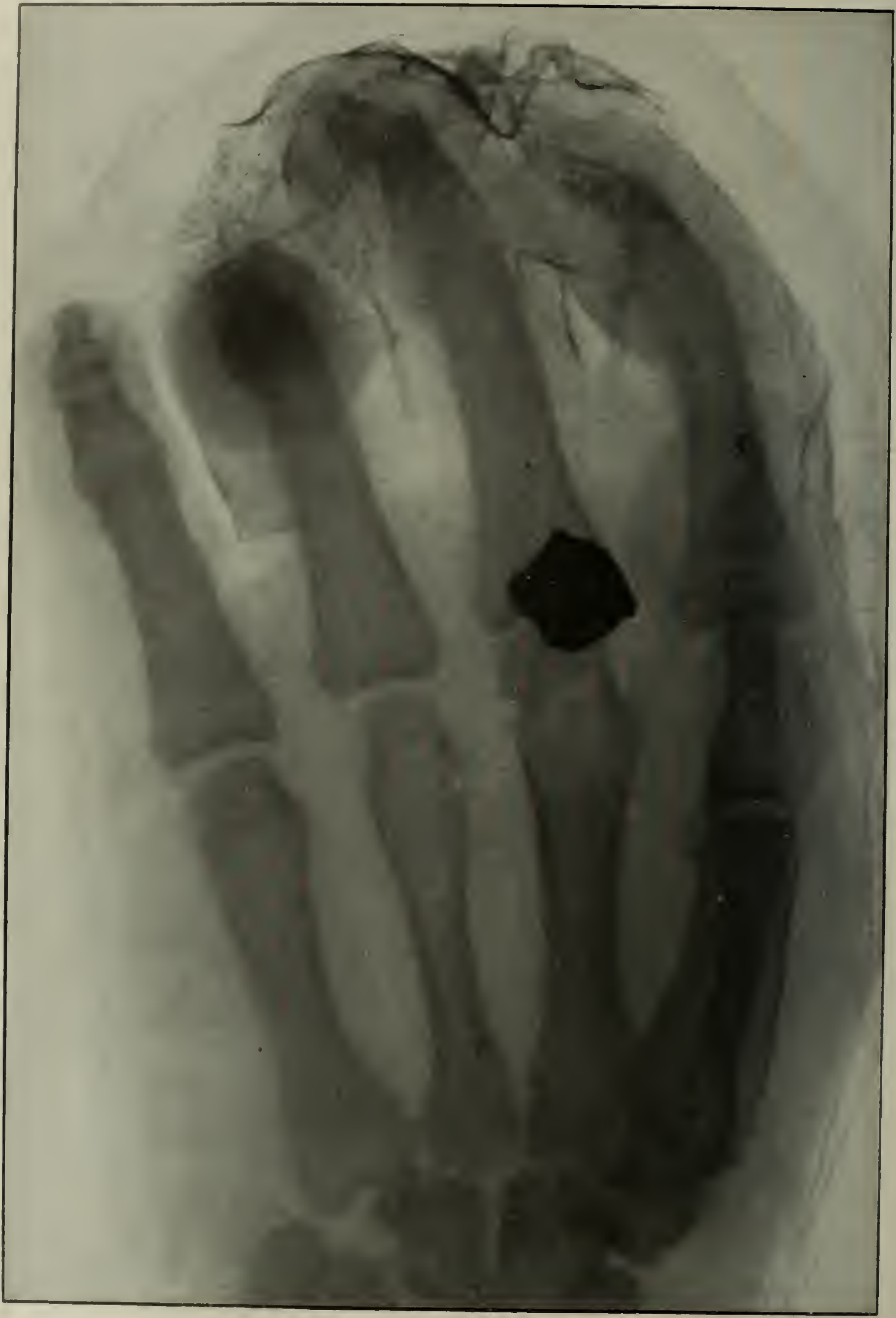
The hand lies with its ulnar side next to the plate, as is indicated by the sharp outline of the swollen hypothenar eminence, nearer the plate than the thumb, with the enlarged, poorly defined, and rarefied shadow of its metacarpal and phalanges.

As the normal size of the balls and the clear outline of the metal fragments must place them almost in contact with the plate, the ball is located near the fifth metacarpal. As this is the same case as is shown in plate 106, the conclusions drawn from each plate are confirmed by the other.

The wound is infected, as indicated by the swelling of the palm.

The treatment is removal of the missile, with management of the infection.

Plate 108.



Shrapnel—Plate 108.

UPPER EXTREMITY.

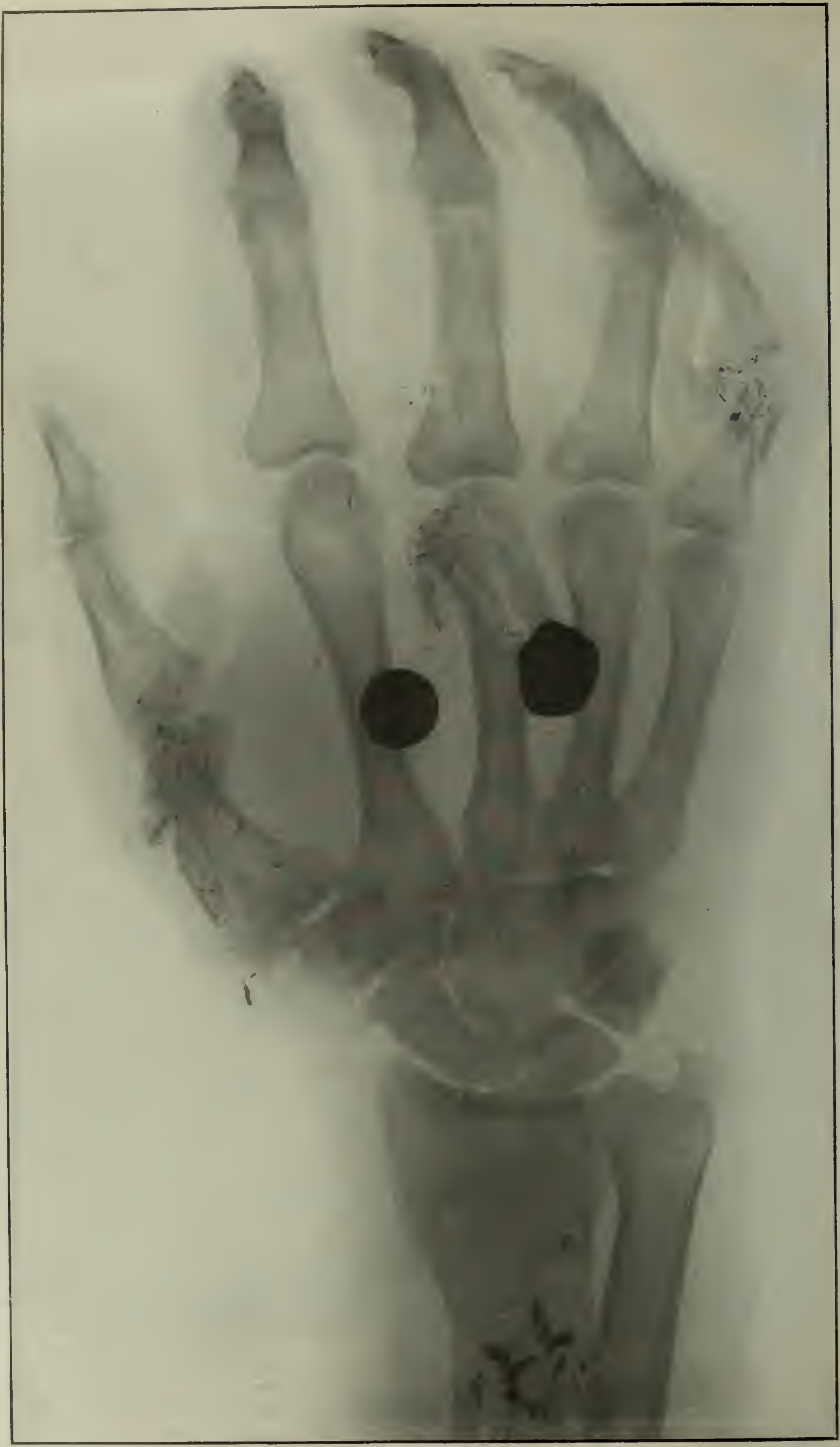
Gunshot Wound of the Left Hand, with Lodgment of the Missile.

The shadow of the hand is shown with the palm next to the plate, as indicated by the small, well-defined outline of the first metacarpal lying within the outline of the larger and less-defined shadow of the second metacarpal. The third finger is flexed at the first phalangeal joint, and the end of the second phalanx is outlined in deeper shadow, with its long axis vertical to the plate.

The position raises the first finger from the plate and very slightly enlarges the size of the shadow of the bullet, although it retains its sharp outline. The shadow of the ball being very nearly the normal size, the ball lies on the palmar side of the third metacarpo-phalangeal joint. It entered the hand on the outer border of the base of the first finger, and left a fragment of metal on its slight contact with the bone. The ball was deformed by ricochet before striking the hand, with almost completely spent velocity. The wound is infected.

The treatment is the management of infection.

Plate 109.



UPPER EXTREMITY.

Multiple Gunshot Wounds of the Right Hand and Forearm, with Fracture of the Metacarpus and Phalanges and Lodgment of the Missile.

The hand lay with the palmar surface next to the plate. The distinct outline of the small metal fragments and the natural size of the shadow of the undeformed shrapnel ball show that they lay on the anterior side of the metacarpus. The arrangements of the metal particles and bone fragments and the indication of the point of entrance of one wound on the outer border of the metacarpal of the thumb indicate the course of the balls to have been from the radial to the ulna side of the palm. The undeformed ball, then, lies, most probably, in front of the second metacarpal. The deformed ball shows, in its enlarged shadow and not so distinct in outline as the normal ball, that it is on the dorsal surface of the third and fourth metacarpals.

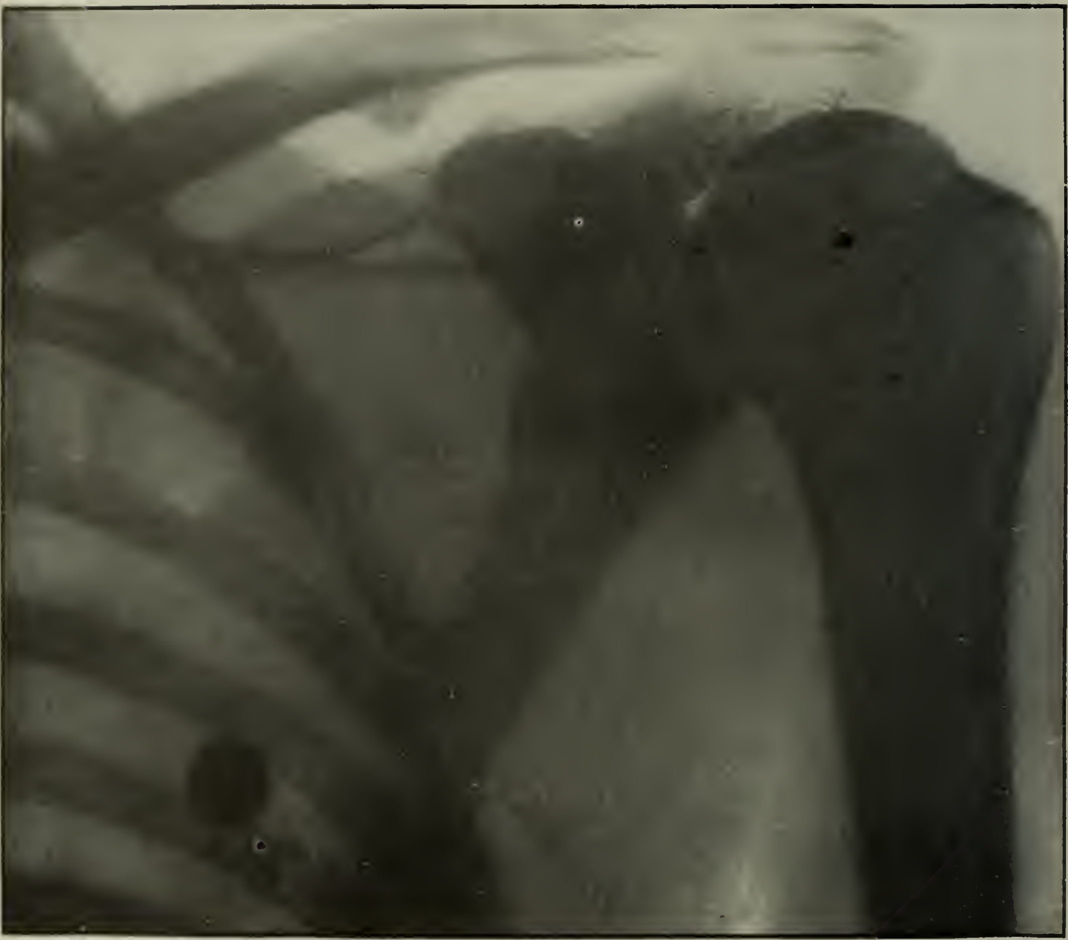
The undeformed ball caused the fracture of the phalanx and metacarpal of the thumb; the deformed ball fractured the neck of the third metacarpal; a ball which escaped from the wound and touched the base of the first phalanx of the middle finger and fractured the first phalanx of the little finger; and another ball, which glanced along the anterior surface of the lower end of the shaft of the radius and left a deposit of metal to mark its course, also escaped from the ulnar border of the forearm at a point indicated in the plate.

Four balls were concerned with this wound; two of them have lodged with some damage and two others have escaped, after inflicting a slight injury. Multiple shrapnel wounds are common. It may be said that the greater the number of balls lodged in a given area the less the distance of the plane from the apex of the cone of dispersion of a shrapnel discharge.

Several shrapnel balls, lodged in a small area without causing much damage or exhibiting much power of penetration, indicate low velocity at close range of shrapnel balls on discharge from the shrapnel envelope.

In a personal case, eight shrapnel balls were removed from a forearm.

Plate 110.



SHRAPNEL—PLATE 110.

CHEST.

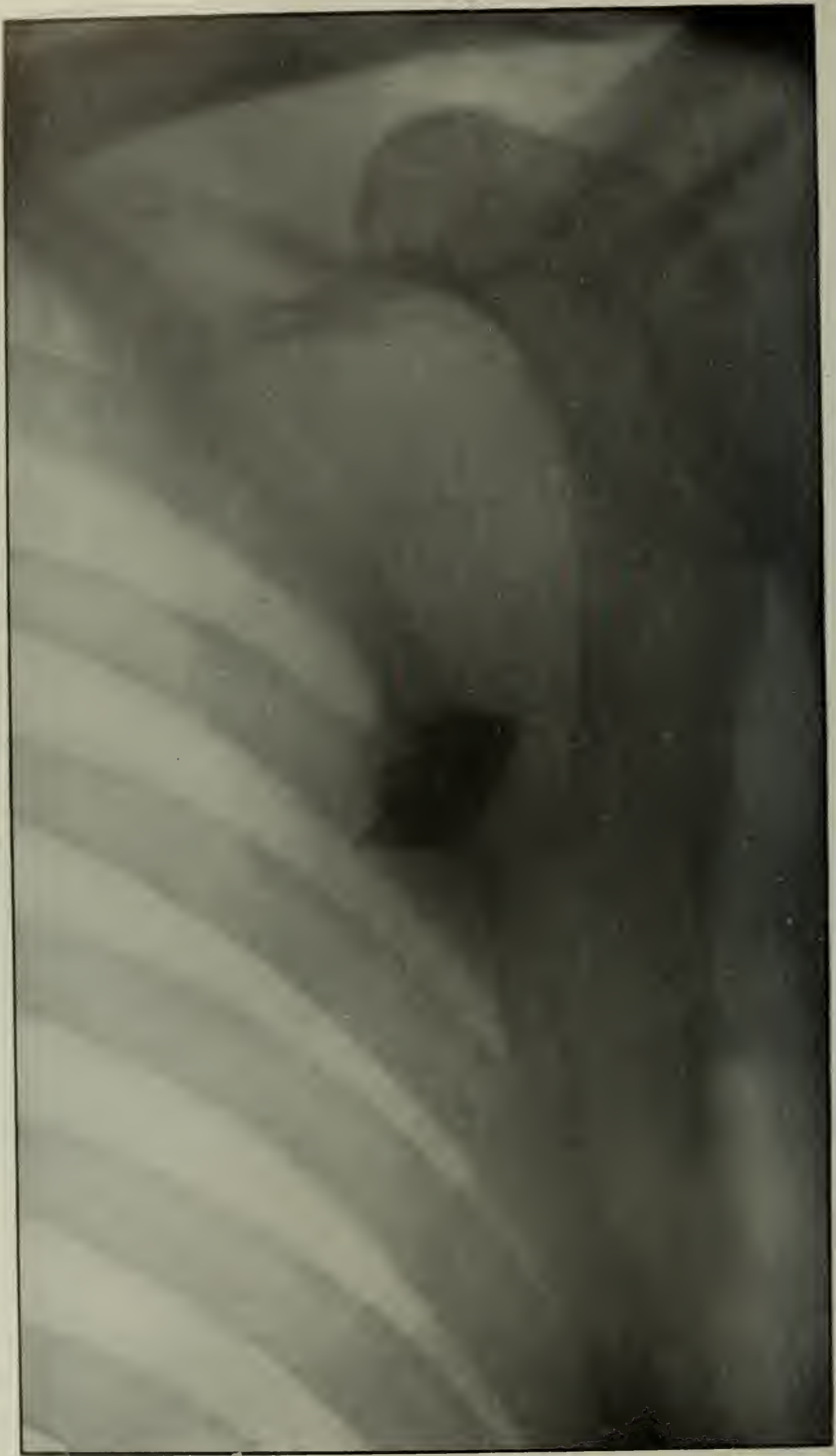
Gunshot Wound of the Chest, with Lodgment of the Missile in the Lung.

The posterior chest wall is next to the plate, as the posterior rib shadows are much more distinct and much smaller than the shadows of the anterior ribs.

The shadow of the ball is blurred, which shows that it moved with respiration and is, therefore, probably in the lung. The shadow is only slightly enlarged and is fairly dense, which indicates it to be not far from the ribs and, therefore, in the posterior portion of the lung.

The treatment of such cases is conservative; infection is not common; hæmothorax pleurisy, empyema, pneumonia, and pulmonary abscess are most frequent complications, named in the order of frequency. Pulmonary abscess is very rare. Pneumonia was seen in a personal case.

Plate 111.



Shrapnel—Plate 111.

CHEST.

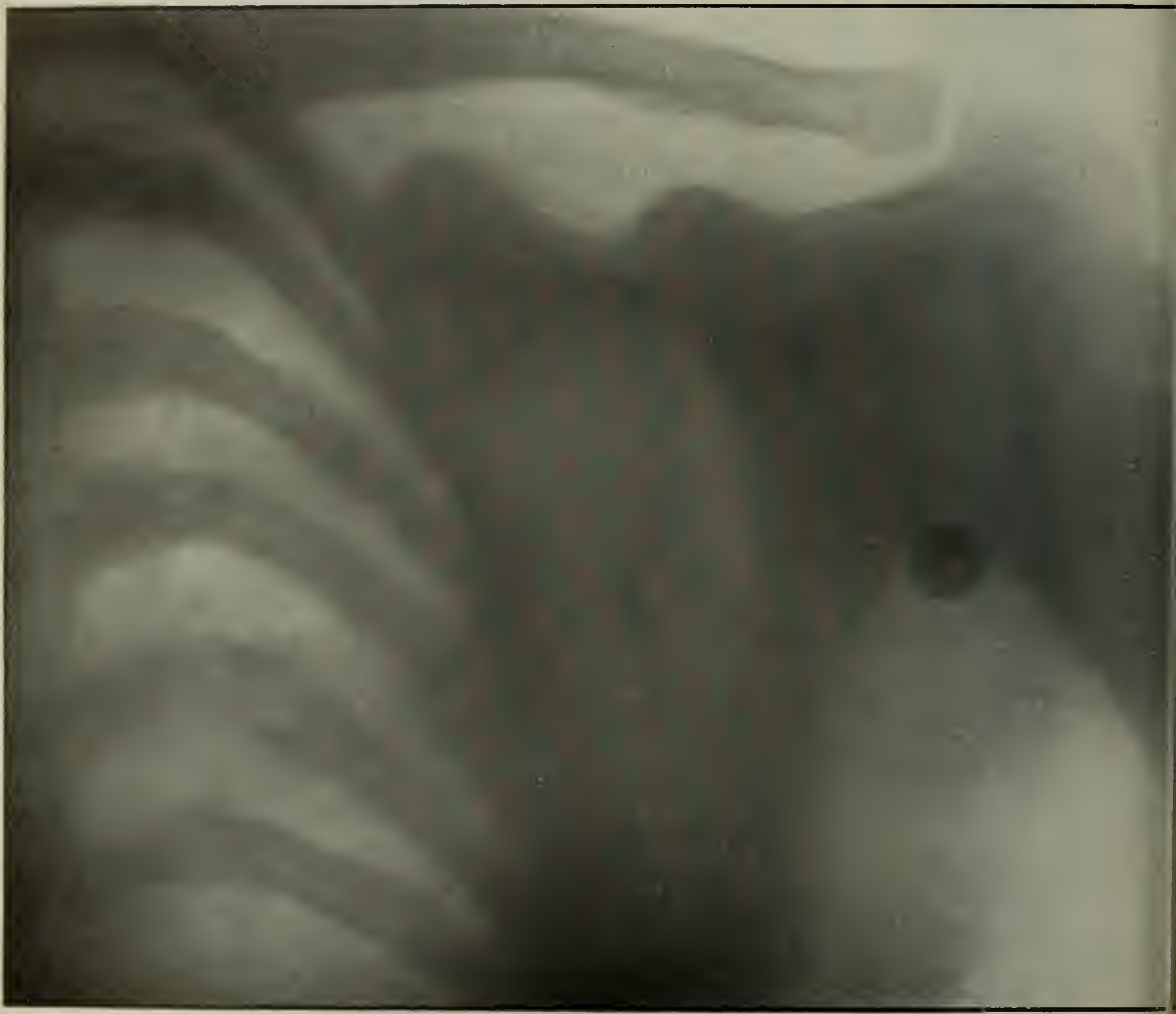
Gunshot Wound of Chest, with Lodgment of the Missile Superficially.

While the missile is not a shrapnel ball, it presents similar conditions and does not need to be separately classified.

The vertebral border of the scapula is distinctly shown in light shadow, indicating its position near the plate.

The outline of the missile is so distinct and the shadow so dense that it must lie near the plate, and is located superficially in the infraspinatus fossa.

Plate 112.



SHRAPNEL—PLATE 112.

CHEST.

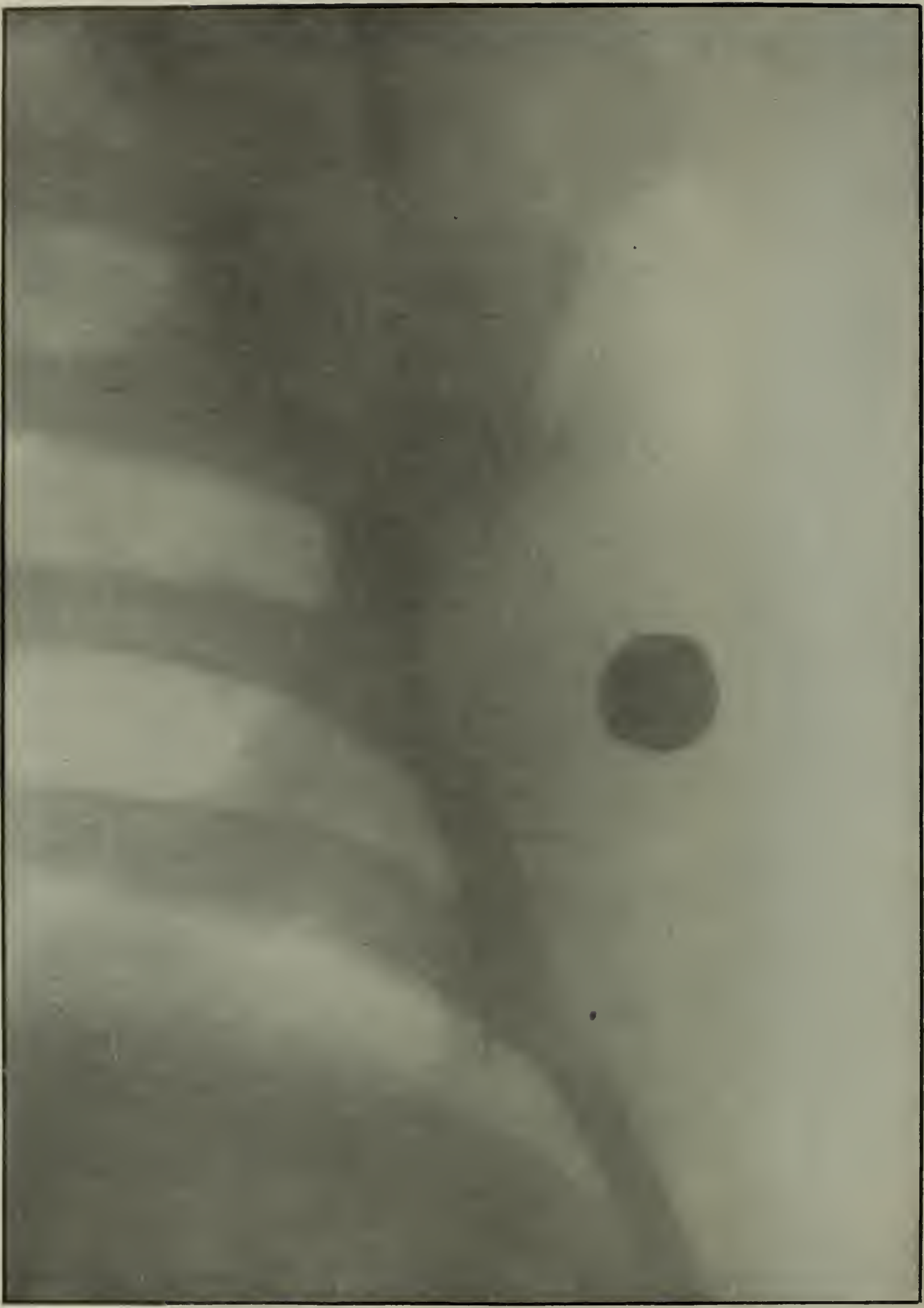
Gunshot Wound of the Chest, with Fractured Rib and Lodgment of the Missile in the Axilla.

The back of the patient lay on the plate, as is indicated by the normal size of the ribs behind and the exaggerated outline in front.

The ball struck the sixth rib behind and caused a fracture at the angle. It then continued its course to the axilla. The normal size of the shadow of the ball indicates that it lies superficially behind the head of the humerus.

The wound of the rib was infected superficially, and the secretion of the wound carried away the most of the metal particles which the ball in striking deposited on impact.

Plate 113.



SHRAPNEL—PLATE 113.

CHEST.

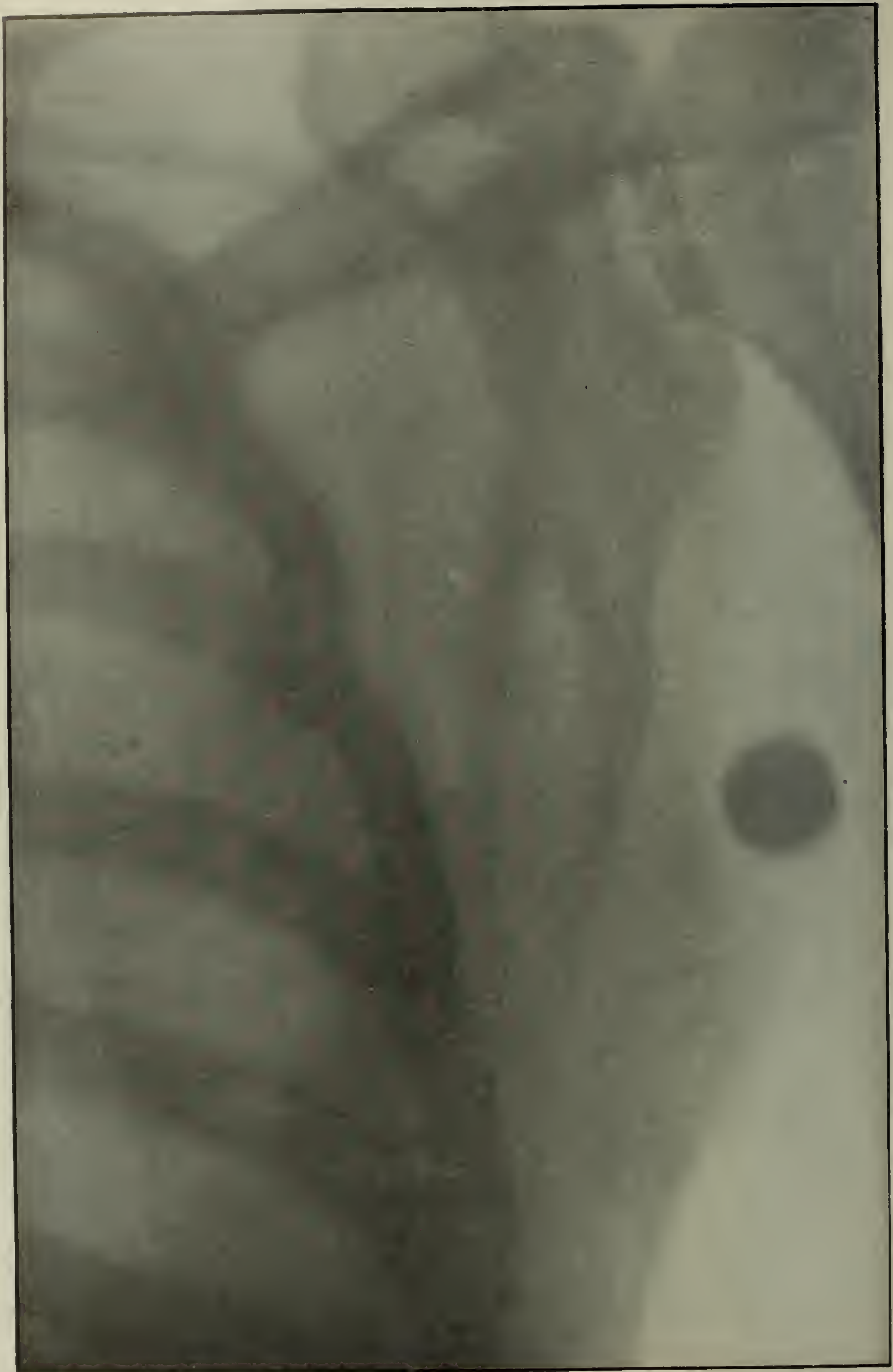
Gunshot Wound of the Chest, with Lodgment of the Missile in the Axilla.

There is no wound of the bone.

The ball lies in the axilla, behind, not close to, the plate, because the density of the shadow is not very great and the size is slightly enlarged. The distance from the plate is probably that of the mid-axillary line.

The wound is not infected. Pain and impaired movement of the arm suggested localization of the missile and indicate removal in the subsequent course of treatment.

Plate 114.



SHRAPNEL—PLATE 114.

CHEST.

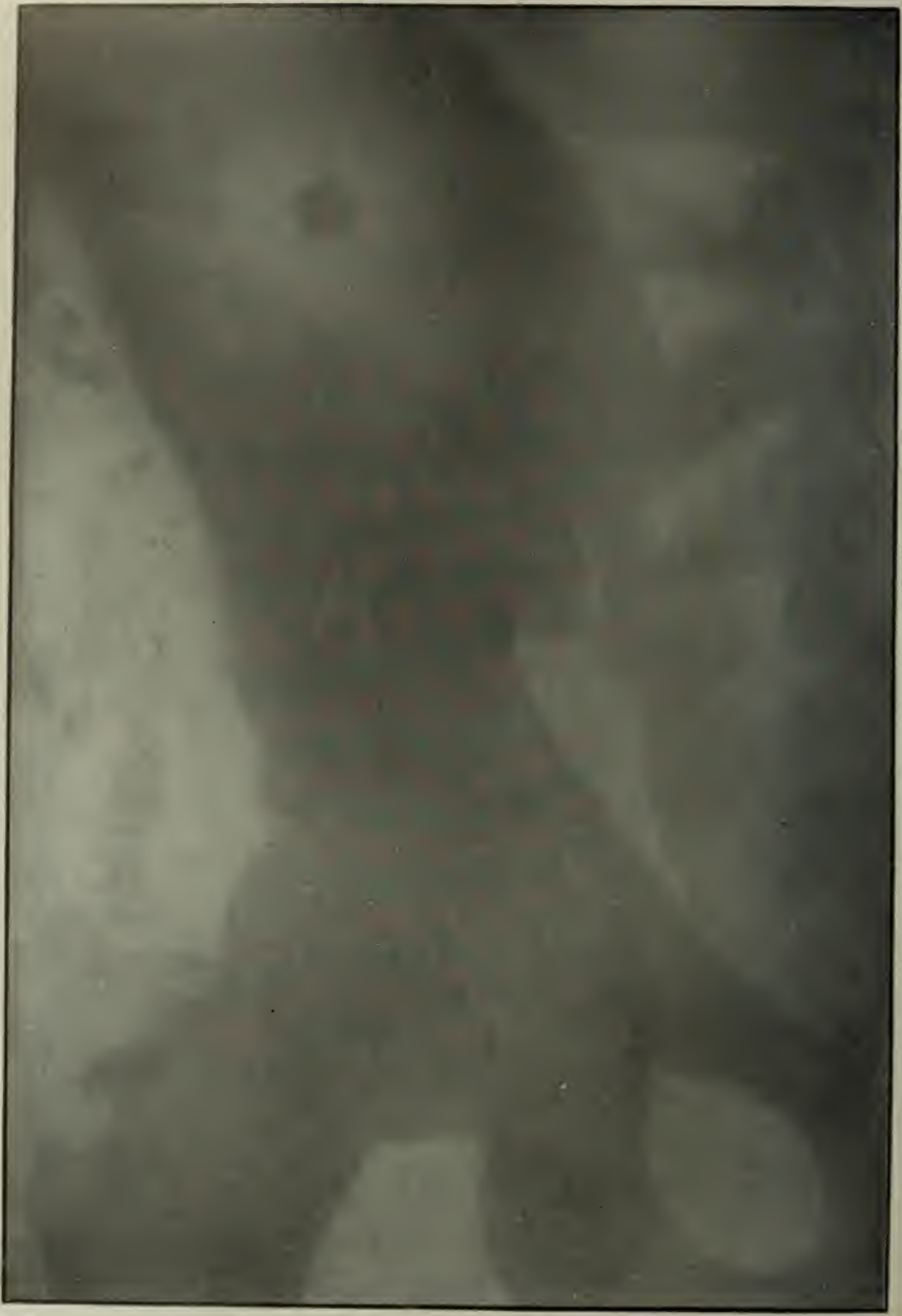
Gunshot Wound of the Chest, with the Lodgment of the Missile in the Axilla.

The posterior chest wall lay next to the plate.

The almost normal size of the shadow of the ball indicates that it lies near the plate, and the blurred outline shows that it has moved with the chest in respiration. The ball lies, therefore, in the posterior axilla near the middle of the outer border of the scapula, imbedded in the thoracic muscles.

The treatment is expectant. Such wounds are rarely infected. Pain or impairment of function only would indicate removal of the missile from a clean wound.

Plate 115.



SHRAPNEL —PLATE 115.

PELVIS.

Gunshot Fracture of the Crest of the Right Ilium, with Lodgment of the Missile.

As the wound was received while the soldier was lying prone, the course of the missile in the body was from above downward, striking the crest of the ilium, on which it was fragmented, and trailing its fragments as far down as the great trochanter. The injury to the ilium was a crushing fracture, with the displacement of small fragments from the antero-superior spine.

As the sacrum was next to the photographic plate, the missile, judging from its indistinct shadow, lies farther from the plate and in front of the bone. The relative distinctness of the large fragment seen on the wing of the ilium indicates its probable position to be on the outside of the ilium.

The trail of the smaller metal fragments lies between the antero-superior spine and the great trochanter, anterior to the plane of the femur.

The treatment in such cases is always conservative.

Plate 116.

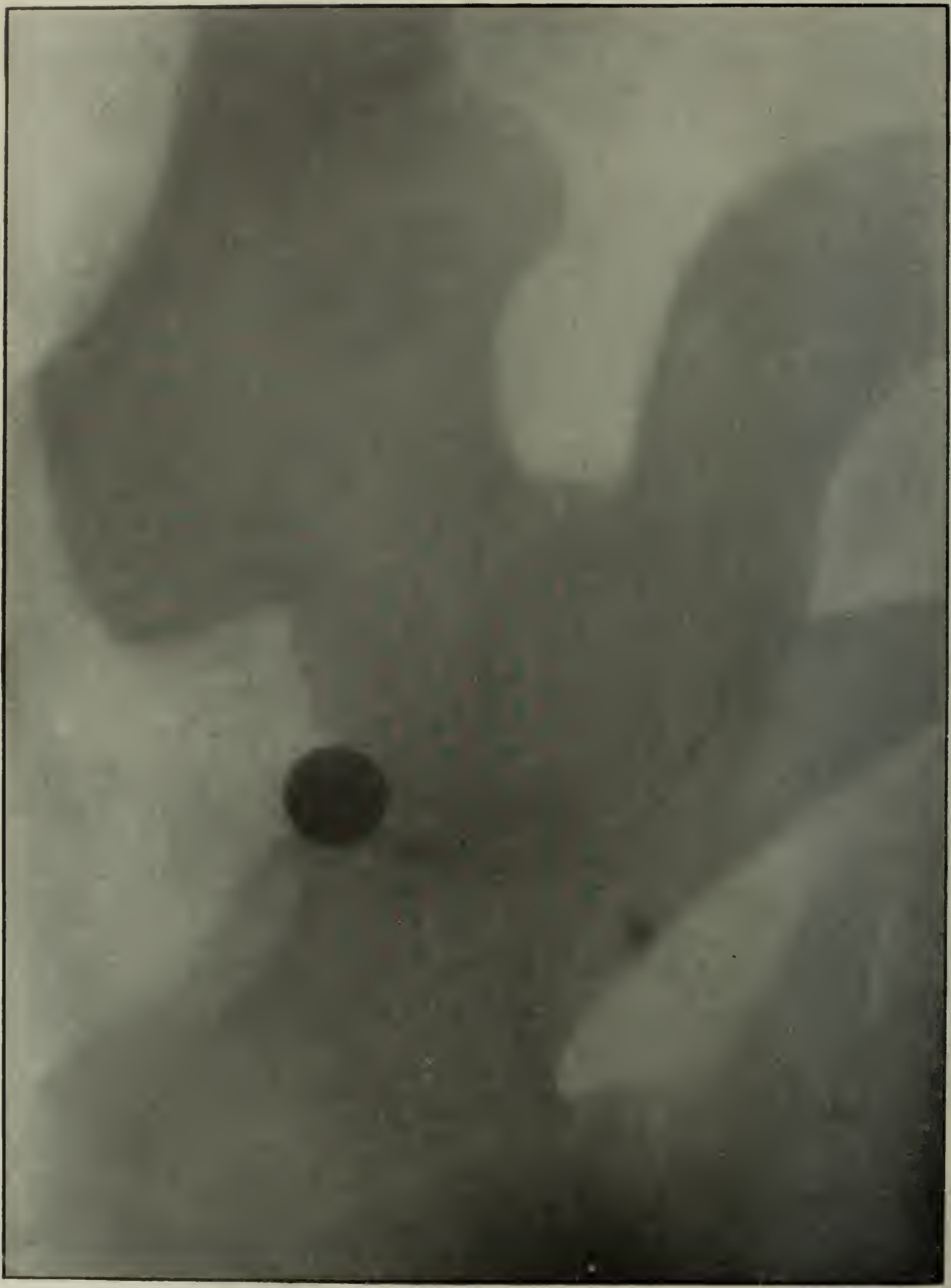
SHRAPNEL—PLATE 116.

LOWER EXTREMITY.

Gunshot Wound of the Thigh, with Lodgment of the Missile.

With the posterior aspect of the thigh lying next to the plate, the very greatly enlarged shadow of the deformed shrapnel ball indicates that it lies a relatively great distance from the plate, so that its location can be determined to be near the internal border of the adductor muscles, anteriorly, and below the transverse plane of the lesser trochanter.

Plate 117.



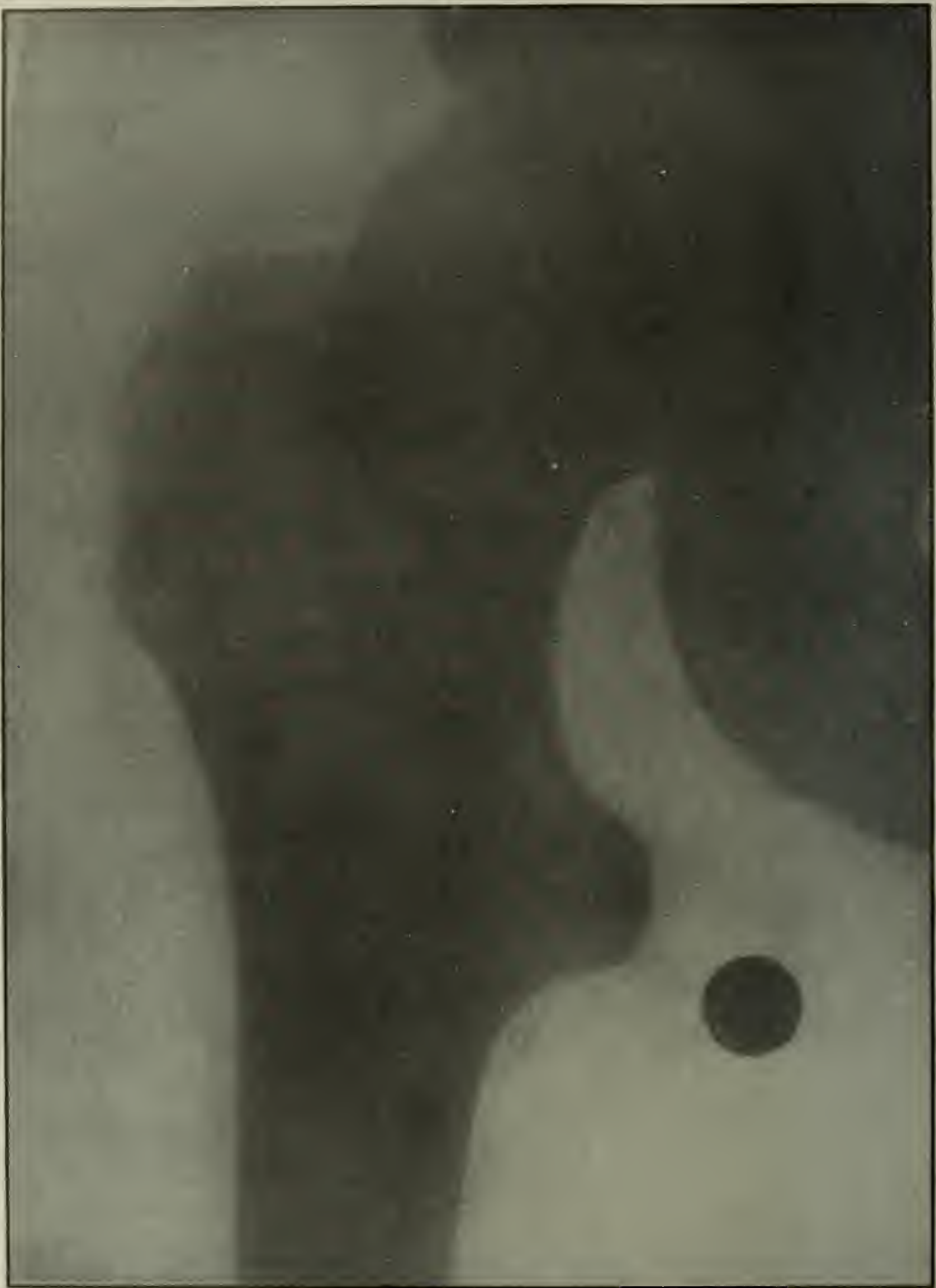
Shrapnel—Plate 117.

LOWER EXTREMITY.

Gunshot Wound of the Thigh, with Lodgment of the Missile.

With the sacrum lying next to the plate, the normal size, clear outline, and dense shadow of the shrapnel ball indicates its position to be near the plate. The location can be roughly estimated as the superficial gluteal region, external to the ramus of the ischium and near the antero-posterior plane of the upper border of the acetabular cavity.

Plate 118.



SHRAPNEL—PLATE 118.

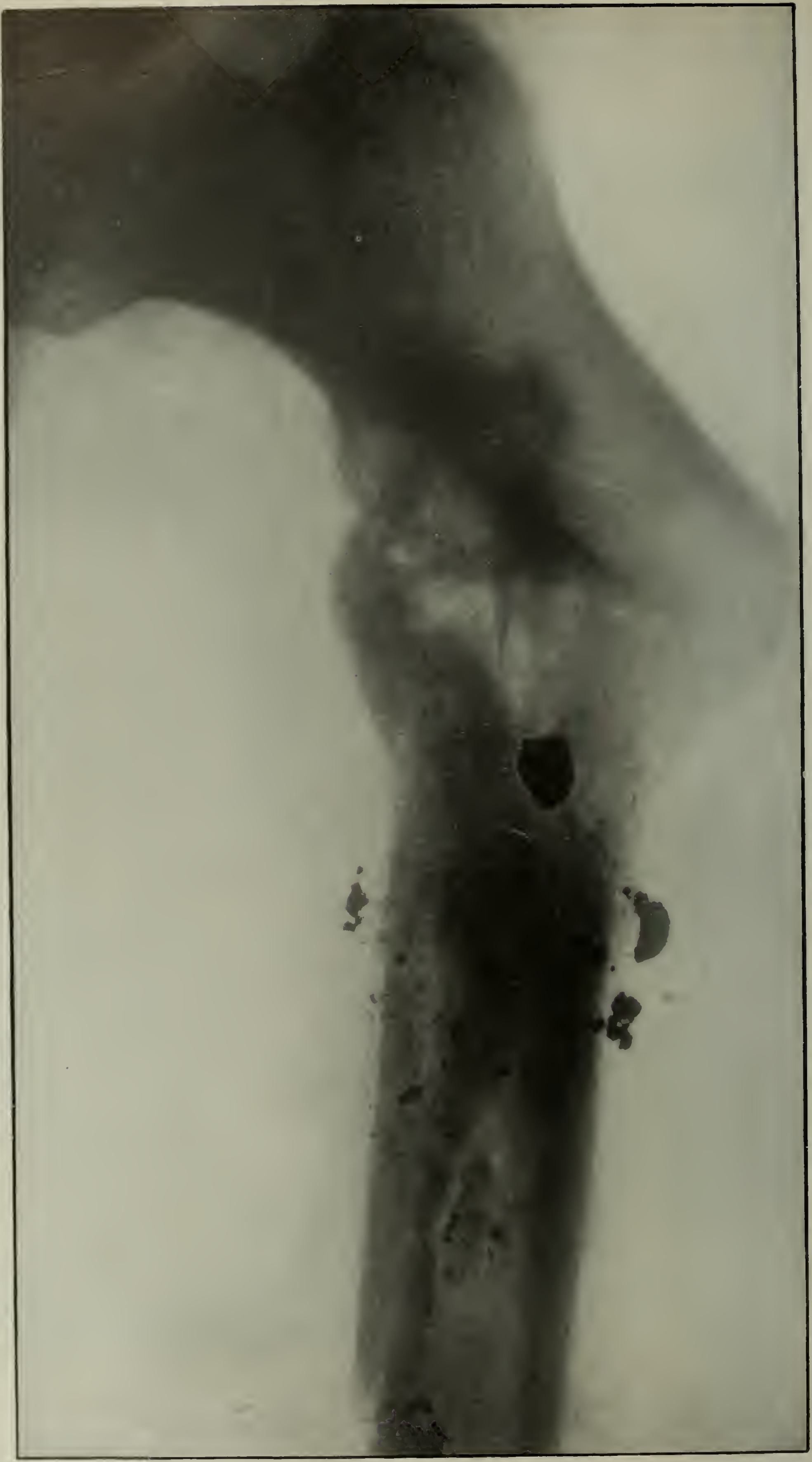
LOWER EXTREMITY.

Gunshot Wound of the Thigh, with Lodgment of the Missile.

The normal size, distinct outline, and considerable density of the shadow of the shrapnel ball show that it lies very near the plate, posterior to the bone and in the buttocks, quite superficially.

The treatment in such cases is always conservative. Pain or impairment of function indicate removal after convalescence.

Plate 119.



SHRAPNEL—PLATE 119.

LOWER EXTREMITY.

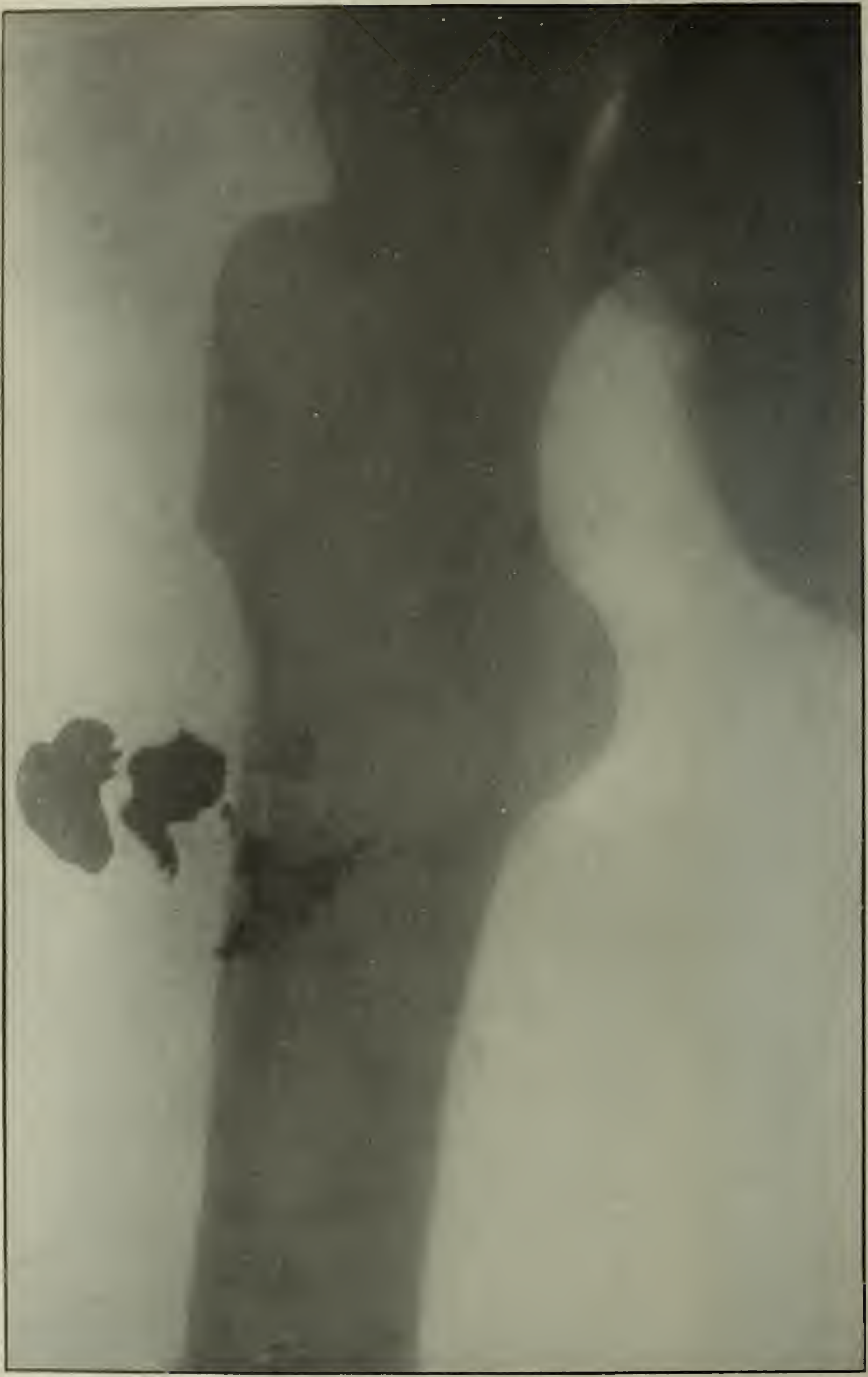
Gunshot Fracture of the Femur, with Lodgment of the Missile.

The direct subtrochanteric impact disintegrated the missile and delivered all of its energy to the bone, with a resulting transverse fracture of the upper end of the shaft of the femur and longitudinal fragmentation of the shaft. The course of the shrapnel ball was from behind forward and from above downward, as is shown by the track of the metal fragments and the lodgment of a larger lead fragment on the shaft below the seat of fracture. The uppermost large lead fragment, as shown by the depth of its shadow, lies farther behind the bone and nearer to the photographic plate than do the other pieces of the ball, as indicated by their lighter shadows. All of the fragments seem to lie behind the bone.

The conservative treatment of this wound is justified by the attempt at repair, as indicated by the callus formation; but it is manifest, from the extremely faulty position, that the indication for immobilization and extension in strong abduction were not appreciated.

Proper management of conservative treatment in such cases gives good results.

Plate 120.



SHRAPNEL—PLATE 120.

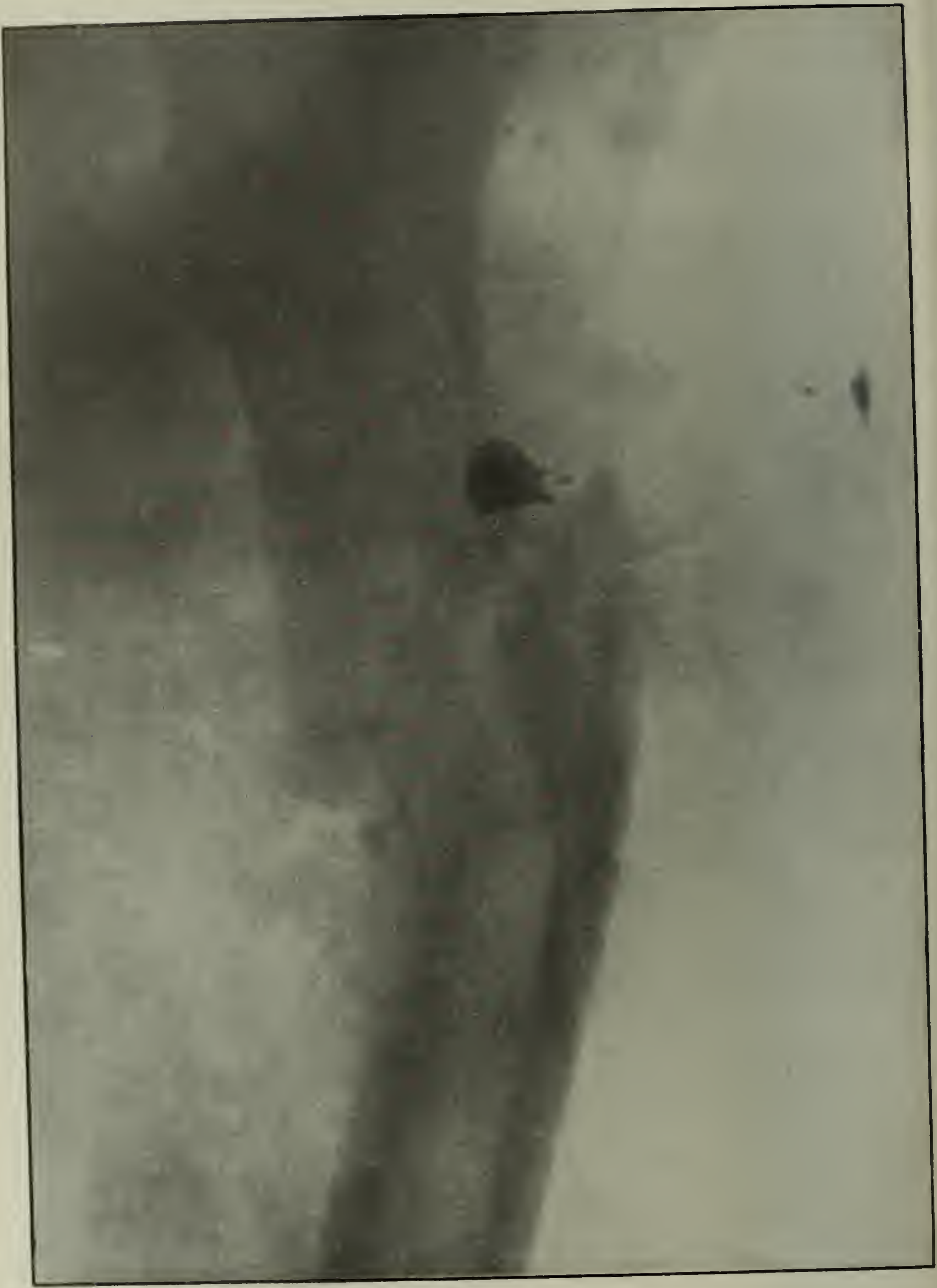
LOWER EXTREMITY.

Gunshot Fracture of the Femur, with Lodgment of Multiple Missiles.

The position of the femur is in outward rotation, as shown by the full shadow of the lesser trochanter and the vanishing of the greater trochanter behind the shoulder of the neck. The two larger missiles lie on the outer side of the bone and the others lie in front on the seat of fracture. The greatly deformed shrapnel balls and the slight chipping fracture of the femur indicate that the greater portion of the striking energy of the missiles was so dissipated in ricochet that but little force was left for attack on the bone.

The treatment in such cases is expectant and indication rarely arises for search for and removal of the missiles.

Plate 121.



SHRAPNEL—PLATE 121.

LOWER EXTREMITY.

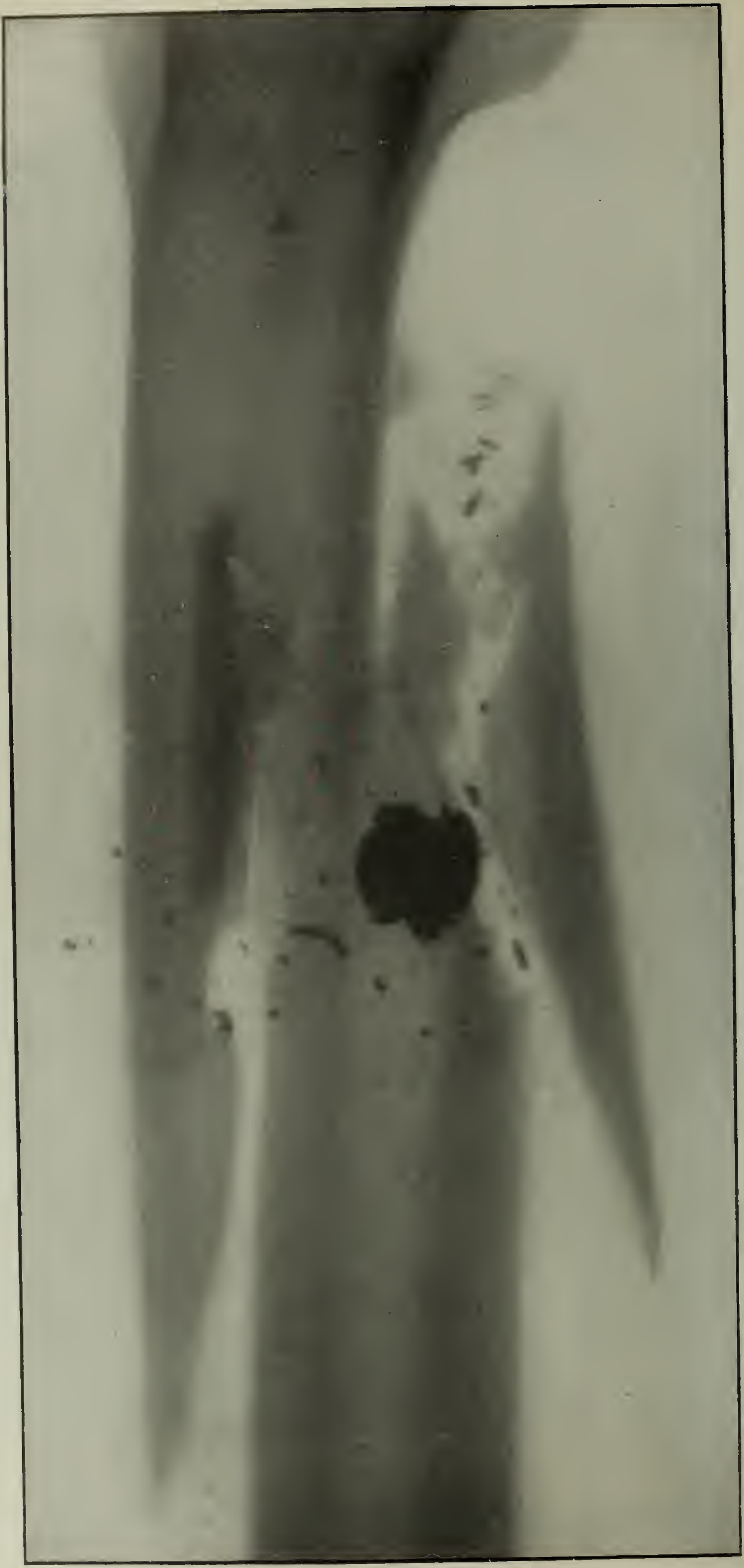
Gunshot Fracture of the Shaft of the Femur, with Lodgment of the Missile.

The course of the shrapnel ball was from within outward, striking the femur with the energy of high (shrapnel) velocity, with fragmentation of the missile by impact on the bone. The largest fragment, by the distinct outline of its shadow, lies close to the plate and behind the bone; a smaller metal fragment has been carried to the outer border of the thigh, where it lies superficially; another fragment lies in the seat of fracture.

The position of fragments is faulty, as the indications for extension and abduction have not been wholly met, although this is a case from the well-conducted service of Gulhane Hospital.

The treatment in such cases is conservative and the results are good.

Plate 122.



SHRAPNEL—PLATE 122.

LOWER EXTREMITY.

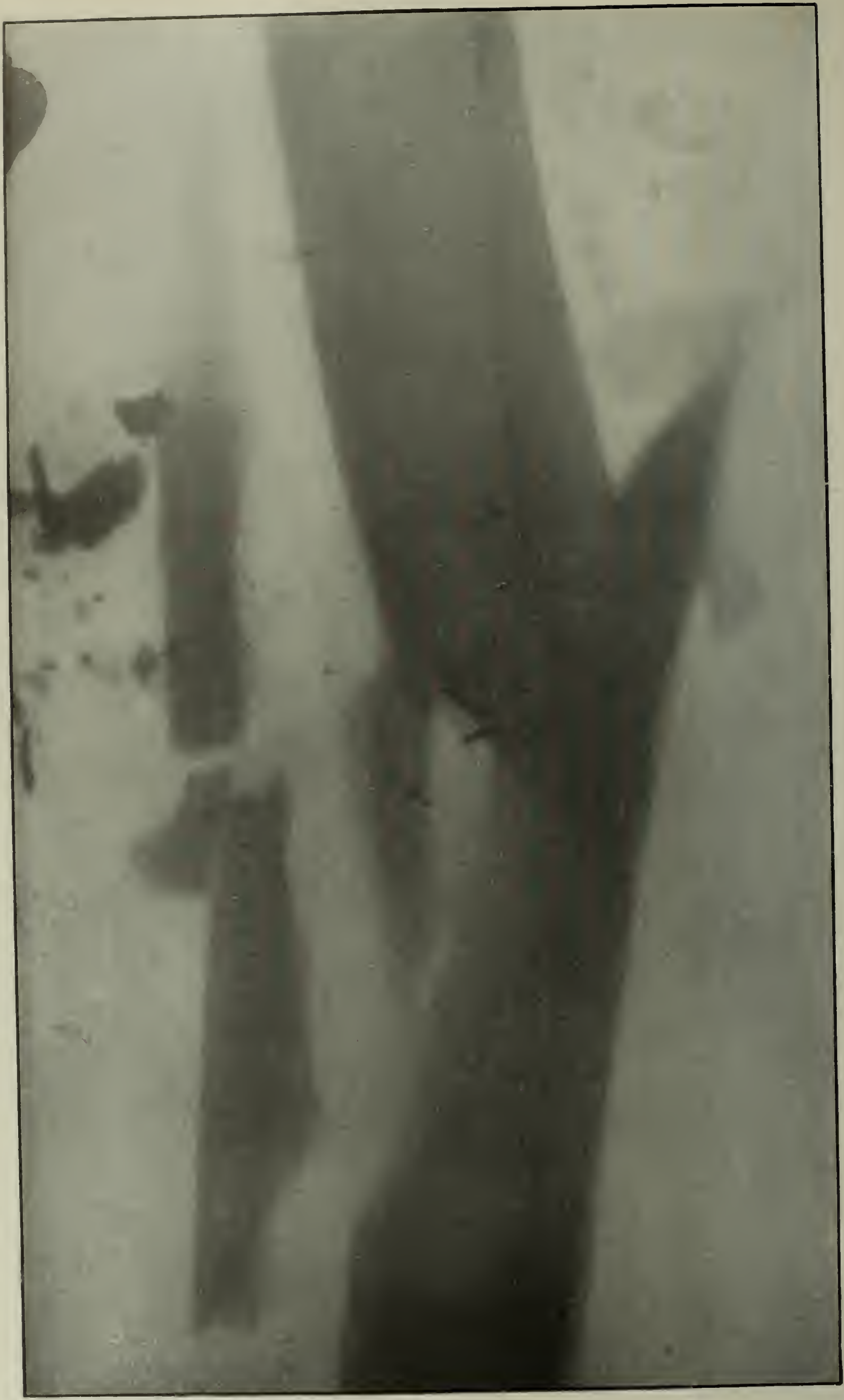
Gunshot Fracture of the Shaft of the Femur, with Lodgment of the Missile.

The shrapnel ball, in its almost directly antero-posterior course from behind forward, has delivered the energy of high (shrapnel) velocity to the bone, which had absorbed it all in stopping the missile, with a resulting approach to a butterfly fracture with displacement of fragments.

The upper end of the lower fragment lies nearer to the plate than to the lower end of the upper fragment, with the deformed shrapnel ball lying behind the latter, closer to the plate.

The treatment in such cases is conservative, with good results to follow except as they may be imperiled by infection.

Plate 123.



SHRAPNEL—PLATE 123.

LOWER EXTREMITY.

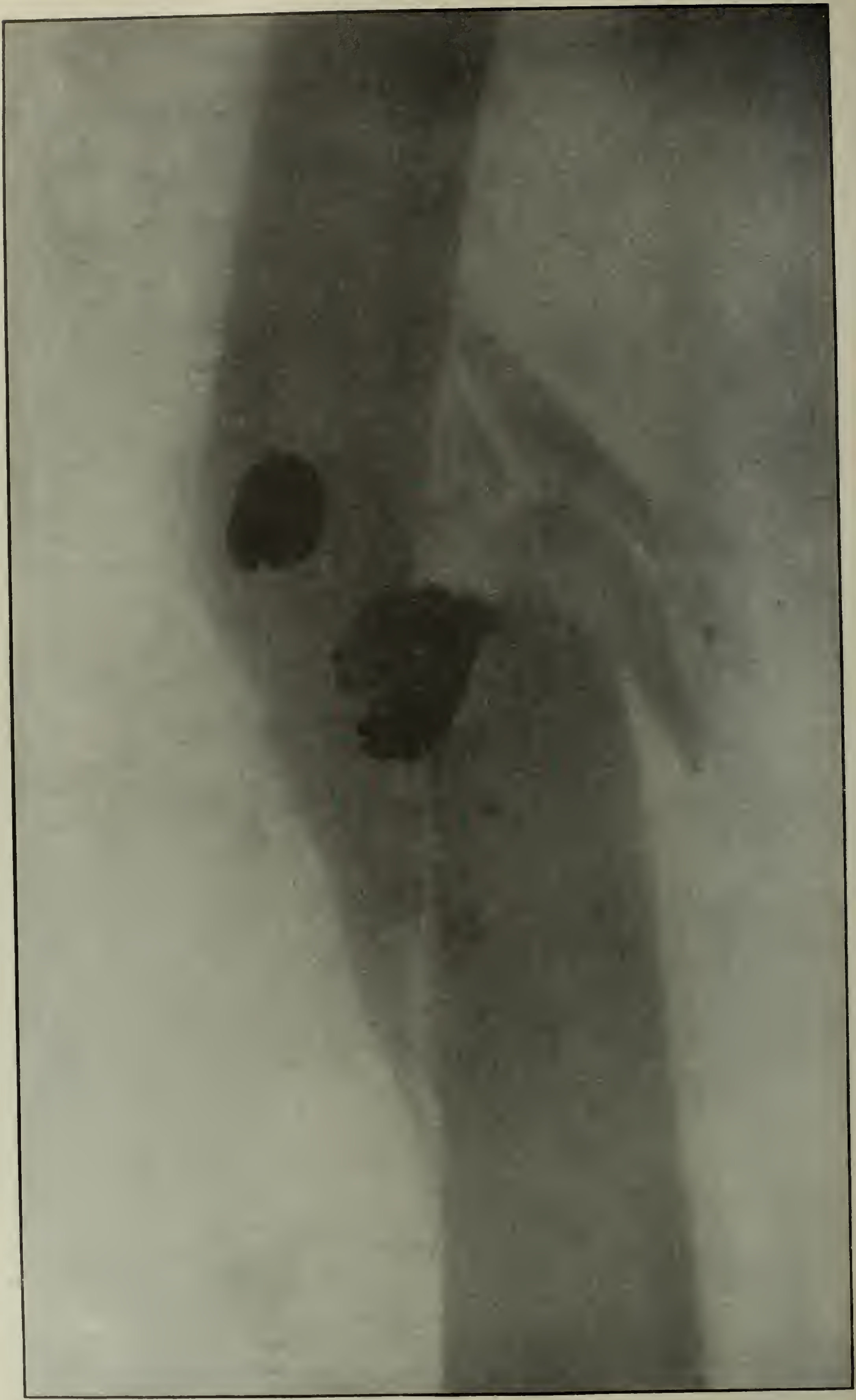
Gunshot Fracture of the Femur, with Lodgment of the Missile.

While the missile in this case may have been other than a shrapnel ball, the fracture is one produced by the impact of a missile delivering great striking energy, with a predominant cross-section factor in its composition. The fragments are due to the application of an energy in which the mass was distributed over a relatively large area on bone, which resulted in the displacement of the large fragments.

The treatment in such cases is conservative.

Results are favorable; infection is generally controlled.

Plate 124.



Shrapnel—Plate 124.

LOWER EXTREMITY.

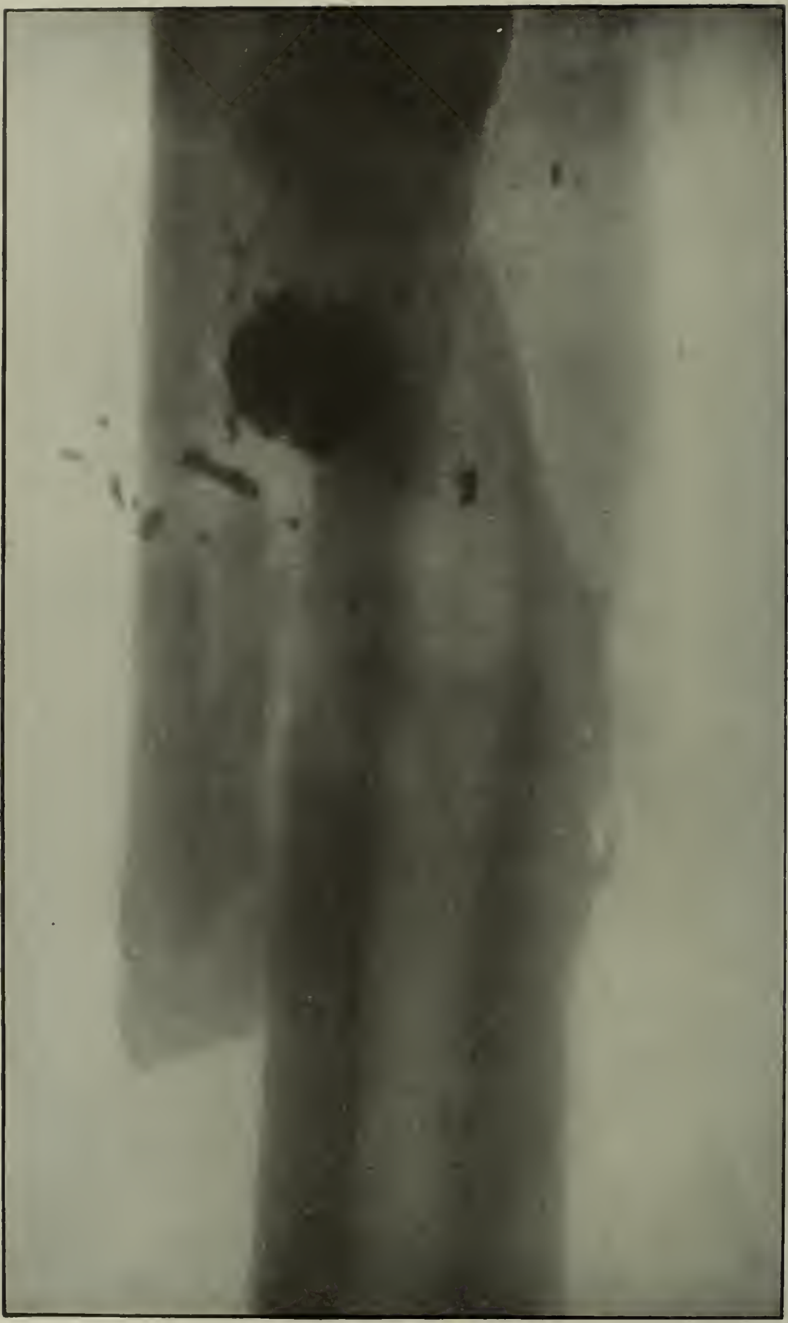
Gunshot Fracture of the Femur, with Lodgment of Multiple Missiles.

The direct impart of two shrapnel balls, delivering all of their energy to the femur, resulted in a fracture with large fragments.

The exposure was made through a plaster splint, and shows a faulty position with progressing repair.

The treatment in such cases is conservative, but with respect for the indications to maintain proper position of the fragments.

Plate 125.



SHRAPNEL—PLATE 125.

LOWER EXTREMITY.

Gunshot Fracture of the Femur, with Lodgment of the Missile.

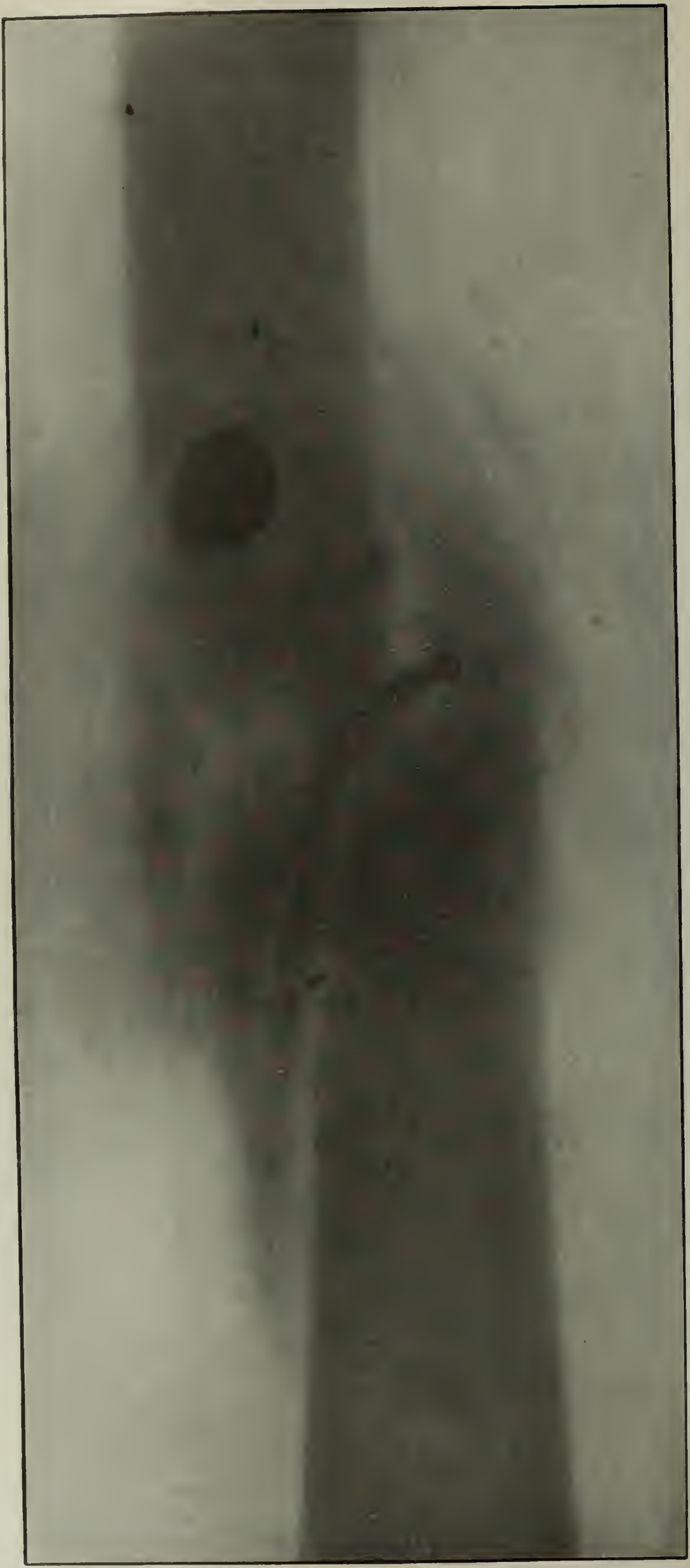
The condition shown in the plate is the characteristic result of direct impact of a projectile of low velocity and great sectional area in which all of the energy is delivered to the bone against which it lodges.

The distinct outline and dense shadow of the deformed missile indicates its position to be behind the bone.

The callus formation indicates the favorable progress of repair, but with the fragments in faulty position.

The treatment in such cases is conservative, with proper respect to the principles of maintenance of normal relation of the fragments.

Plate 126.



SHRAPNEL—PLATE 126.

LOWER EXTREMITY.

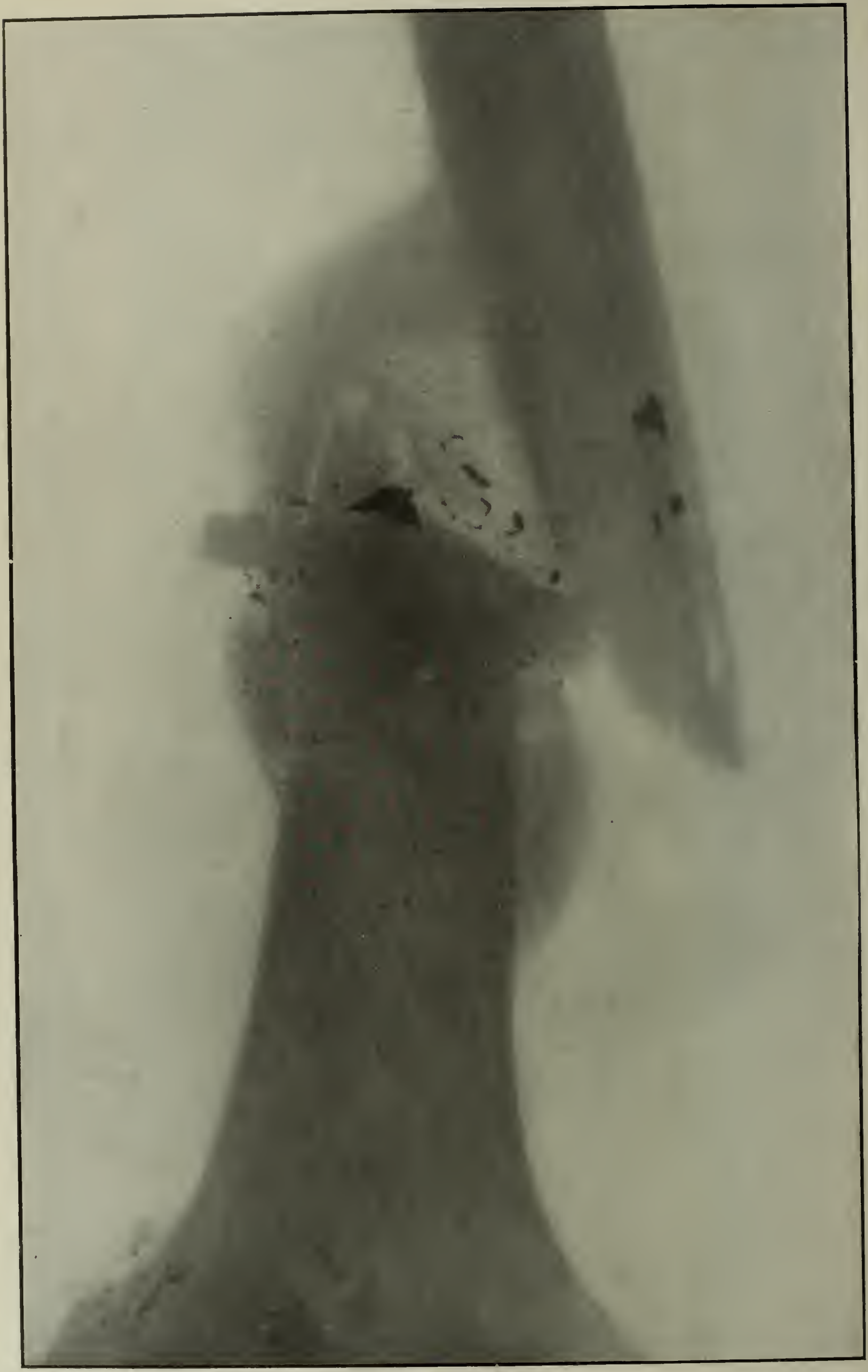
Gunshot Fracture of the Femur, with Lodgment of the Missile.

The course of the shrapnel ball was antero-posterior, with an impact on the shaft of the femur, which fragmented both the ball and bone through the imparting or the entire striking energy of the ball to the bone by the lodgment of the ball. The sharp outline and density of the shadows of the missile, in contrast with the dense shadows of the bone, indicate that the missile lies closer to the plate than does the bone, although the flattened ball does not permit a comparison between its shadow and the normal size of the ball.

The advanced stage of convalescence is shown by the formation of callus.

The treatment in such cases is conservative and the results are good if proper position can be maintained.

Plate 127.



SHRAPNEL—PLATE 127.

LOWER EXTREMITY.

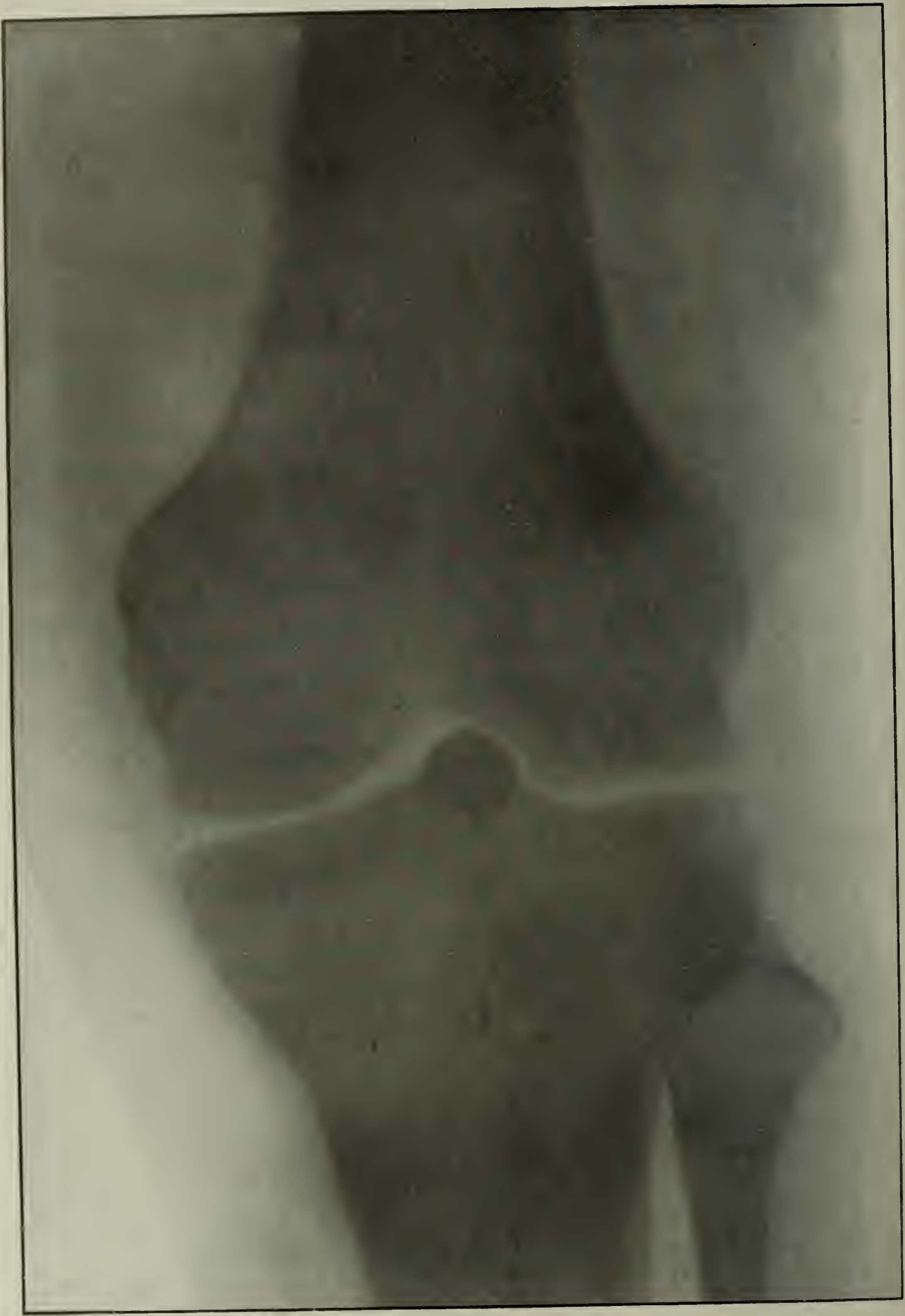
Gunshot Fracture of the Shaft of the Femur.

The impact of the missile was delivered with the energy of high (shrapnel) velocity at close range, as is indicated by the signs of another shrapnel wound, just above the outer tuberosity (in the lower left corner of the plate), where a deposit of metallic particle is evidenced.

The fragmentation of the missile, through its contact with the bone, indicates the great striking force of a missile which ricocheted from the bone. The general distribution of metallic particles through a wound of this class indicates certainly that the missile was unjacketed, and the destructive forces show that its sectional area was relatively larger, i. e., a shrapnel ball.

The hard metal jacket of a rifle bullet would not give off its particles in contact with the bone unless it were so greatly deformed as to have almost entirely lost its jacket. In this state the energy of a rifle ball must be so greatly reduced, through the violence of ricochet, that it would not retain enough striking force to cause its disintegration on impact with the bone. Besides, some particles of the jacket could be identified, as they are always bent or twisted so that their character is recognized in the shadow.

Plate 128.



SHRAPNEL—PLATE 128.

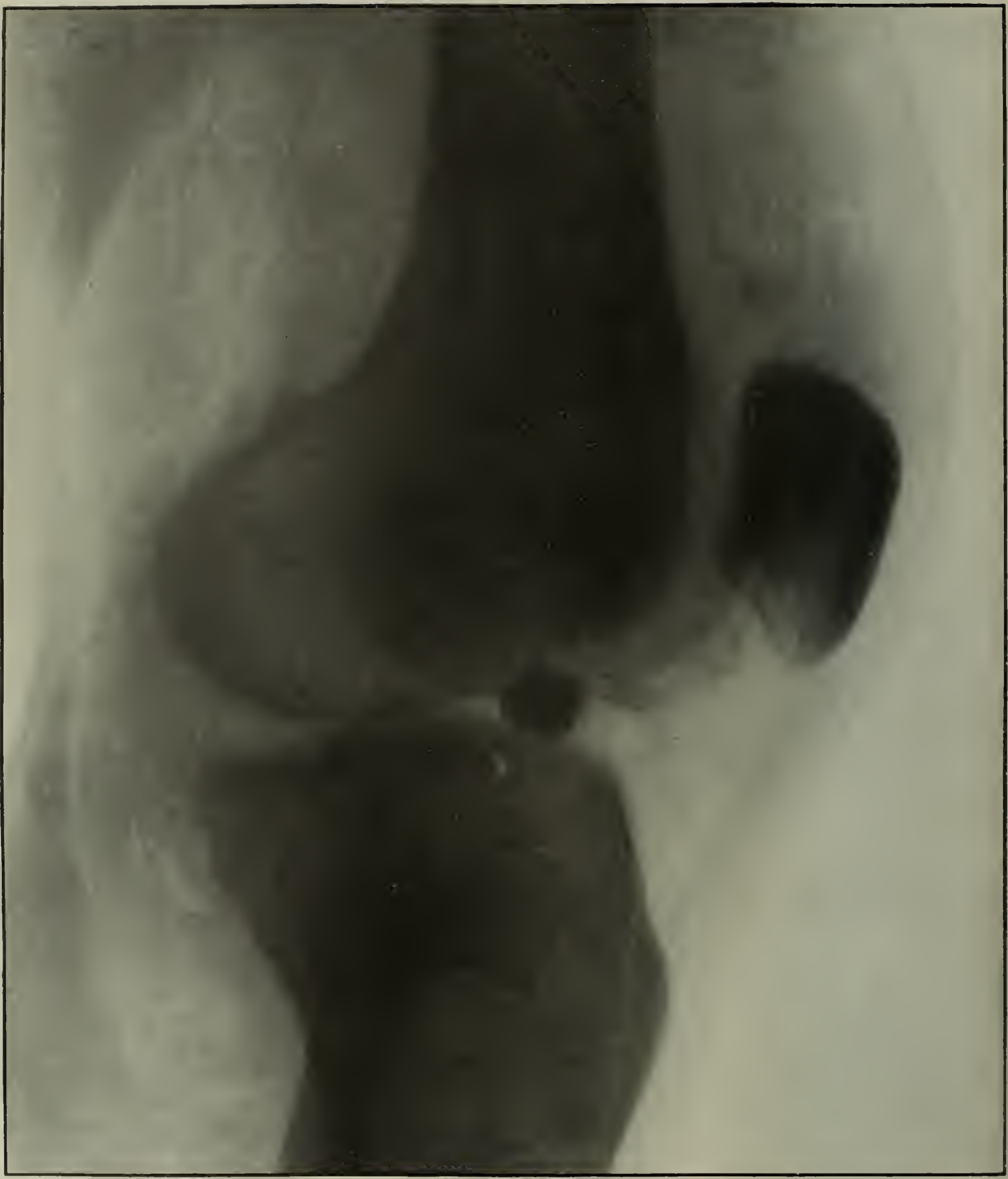
LOWER EXTREMITY.

Gunshot Wound of the Left Knee, with Lodgment of the Missile in the Joint.

The slight enlargement and moderate density of the shadow of the projectile indicates a position a short distance from the plate. A slight shadow dependent from the external condyle on the outside of the ball and a metallic marking just outside of the upper contour of the outer tuberosity indicate an injury to the joint and the path of the ball from above the outer tuberosity into the joint capsule.

The probabilities are that the ball lies between the head of the tibia and the patellar notch of the femur, but the absolute certainty of this deduction must be supported by an exposure in a lateral plane, which is shown in plate 129.

Plate 129.



SHRAPNEL—PLATE 129.

LOWER EXTREMITY.

Gunshot Wound of the Left Knee, with Lodgment of the Missile in the Joint.

As the fibular shadow is about the normal size and clearly outlined, the fibular side of the leg lay next to the plate.

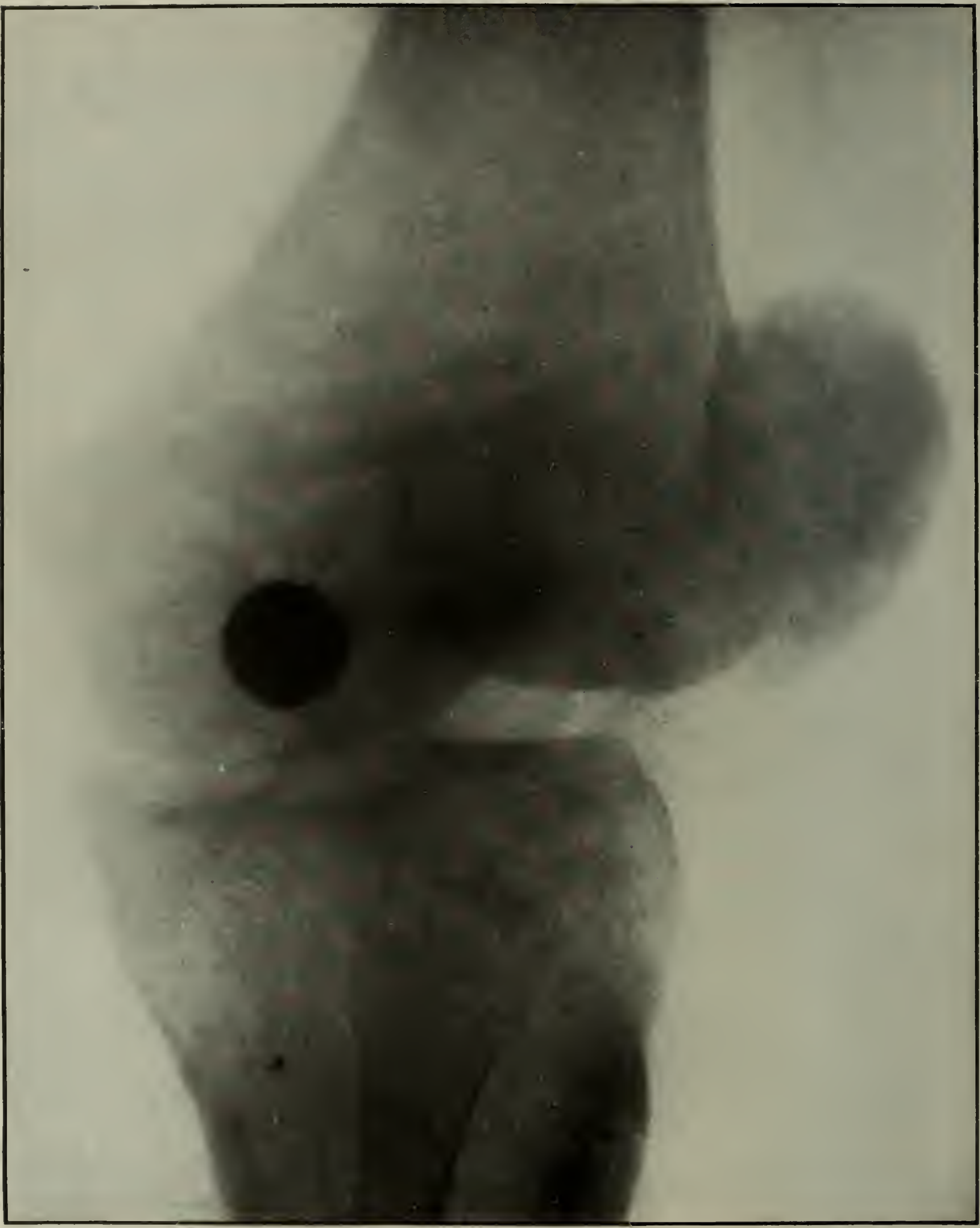
As the shadow of the ball is dense and not much enlarged, it must lie near the plate. A light shadow in front of the ball, which shows the anterior crucial ligament, and a metallic marking above the patella, suggests the path of the ball.

As this is a lateral projection of the same case that is shown in plate 128 in an antero-posterior projection, these conclusions are thus verified.

The missile lies in the joint capsule between the head of the tibia, in front of the spine, and the patellar notch of the femur.

As a foreign body in the knee joint which seriously interferes with its function, removal is indicated when surgical facilities are at hand. The results in such cases are usually good.

Plate 130.



SHRAPNEL—PLATE 130.

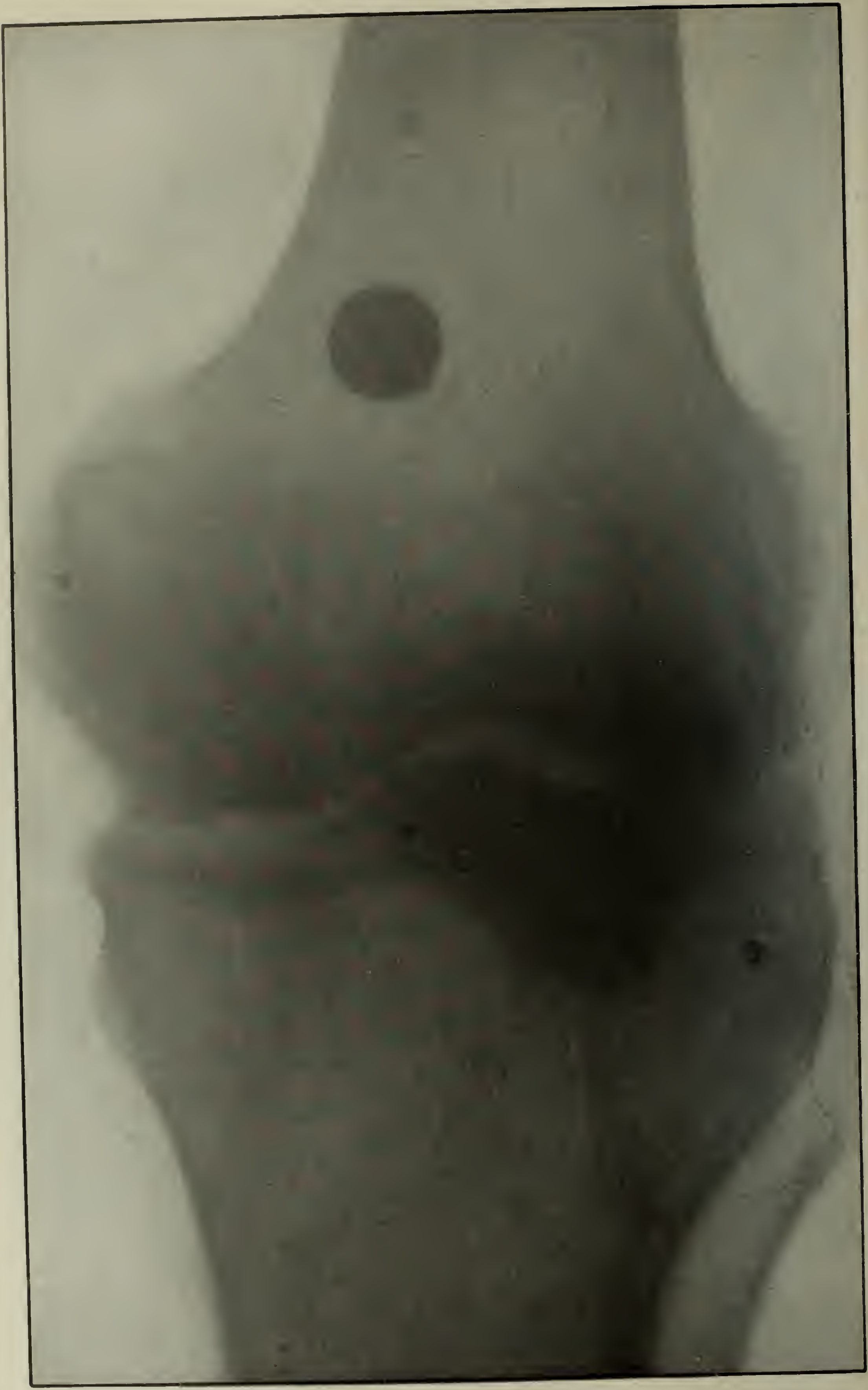
LOWER EXTREMITY.

Gunshot Wound of the Left Knee, with Lodgment of the Missile in the Joint.

The line of projection of the shadow is directed obliquely from behind, focussed on the internal aspect of the knee, with the fibula next to the plate. As the shadow of the shrapnel ball is much enlarged and not very dense, the ball must lie some distance from the plate and away from the fibular side of the joint. As the distances through the knee joint are about the same in all cases and as shrapnel balls are approximately the same size, it is evident that the ball lies farther away from the plate than it does in plate 129, where it is about the middle of a transverse line through the joint. It must lie, therefore, superficially between the head of the tibia and the internal condyle of the femur.

Removal is indicated under favorable surgical conditions. Infection of the joint may occasionally indicate drainage and removal as emergency treatment.

Results, except for infection, are good.



SHRAPNEL—PLATE 131.

LOWER EXTREMITY.

Gunshot Wound of the Knee, with Lodgment of the Missile.

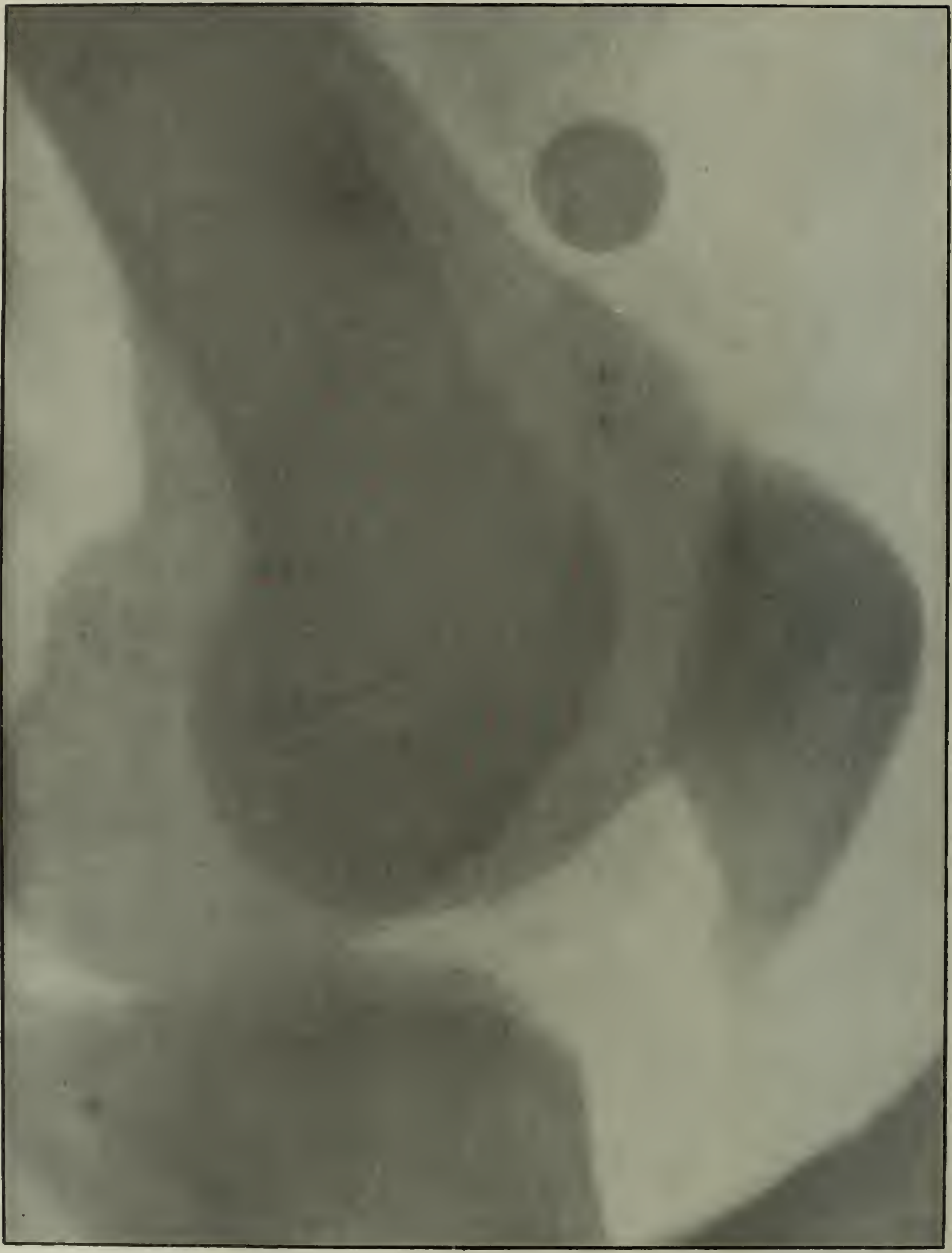
That the knee is not fully extended is shown by the exaggerated outline of the tibial head.

The enlarged and only fair density of the shadow indicates that the shrapnel ball lies some distance away from the plate. As the bone is not injured, the missile must lie either in front of or behind the femur, and its enlarged shadow shows the position to be in front of the femur, just above the articular surface, and probably within the reflection of the capsular ligament.

A comparison with the size of the shadows of the balls shown in plates 128 and 130 will show this one to be greater than the former and less than the latter, and so it must bear about the same relation in the distance from the plate. This would account for the location in front instead of behind the femur.

The treatment is conservative, and removal is indicated when function is disturbed.

Plate 132.



SHRAPNEL—PLATE 132.

LOWER EXTREMITY.

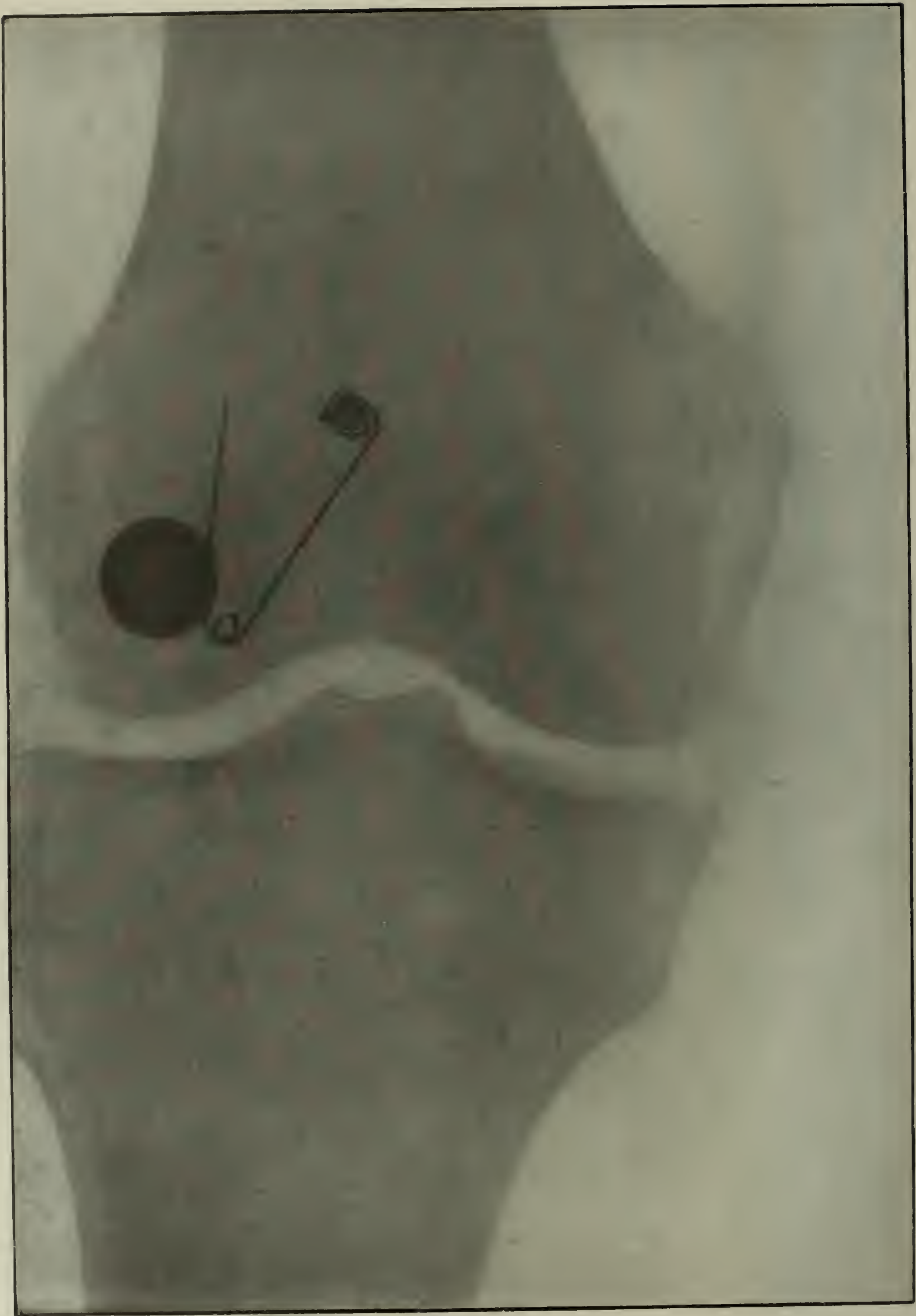
Gunshot Wound of the Knee, with Lodgment of the Missile.

The fibular side of the leg lay next to the photographic plate, as shown by the enlarged fainter outline of the internal tuberosity.

The shadow of the shrapnel ball is neither as normal in size as that of the external condyle nor as exaggerated as that of the internal condyle, and the position is probably neither as close to the plate as the former nor as far away as the latter.

The missiles lie about the middle of the anterior surface of the lower end of the femur, above the articular surface.

Plate 133.



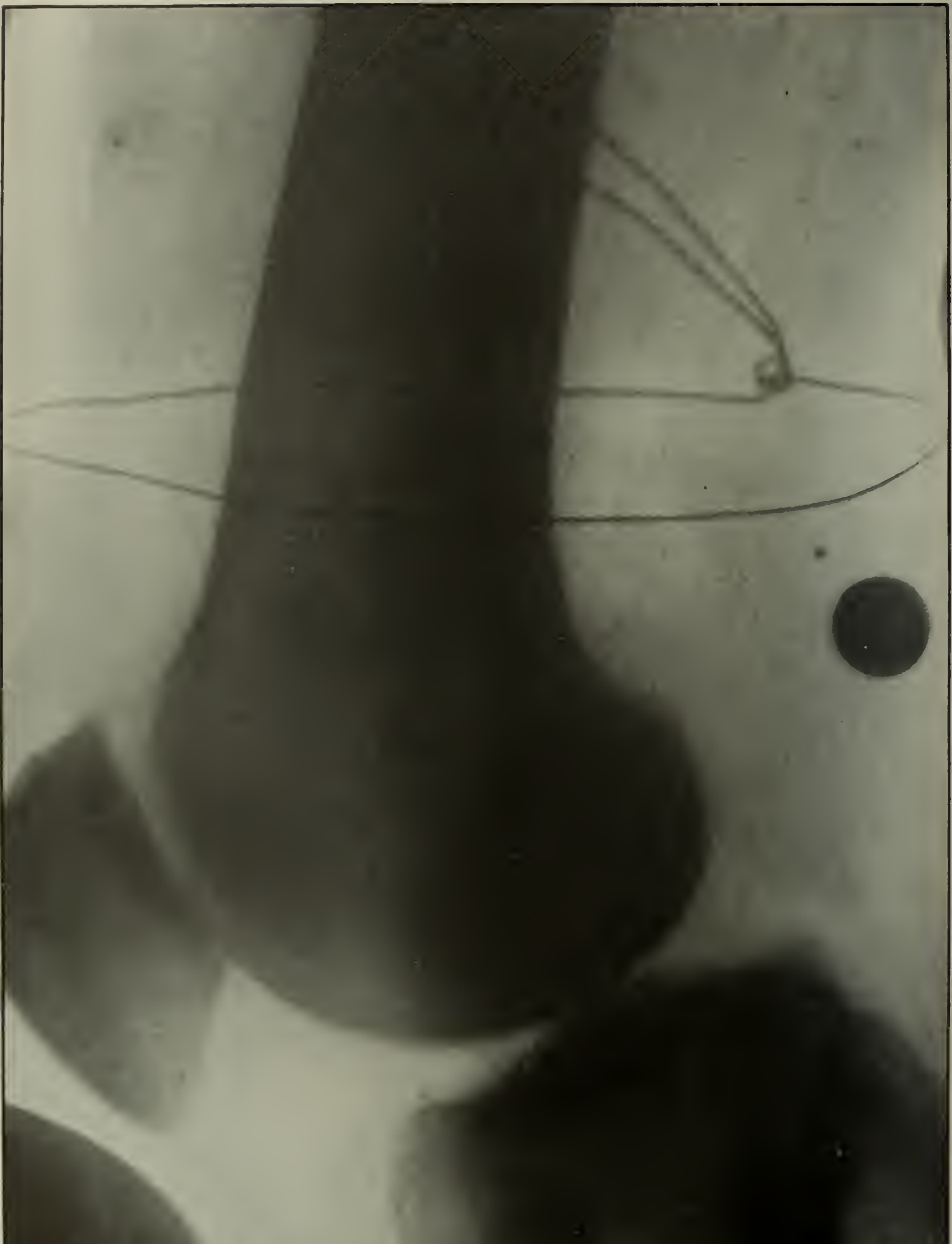
SHRAPNEL—PLATE 133.

LOWER EXTREMITY.

Gunshot Wound of the Right Knee, with Lodgment of the Missile.

The ball struck the outer condyle just above the articular surface with only enough energy to damage and slightly crack the bone. The injury to the bone and the metallic mark of the impact can be seen just above the outer border of the articular cartilage of the outer condyle.

Plate 134.



SHRAPNEL—PLATE 134.

LOWER EXTREMITY.

Gunshot Wound of the Left Knee, with Lodgment of the Missile.

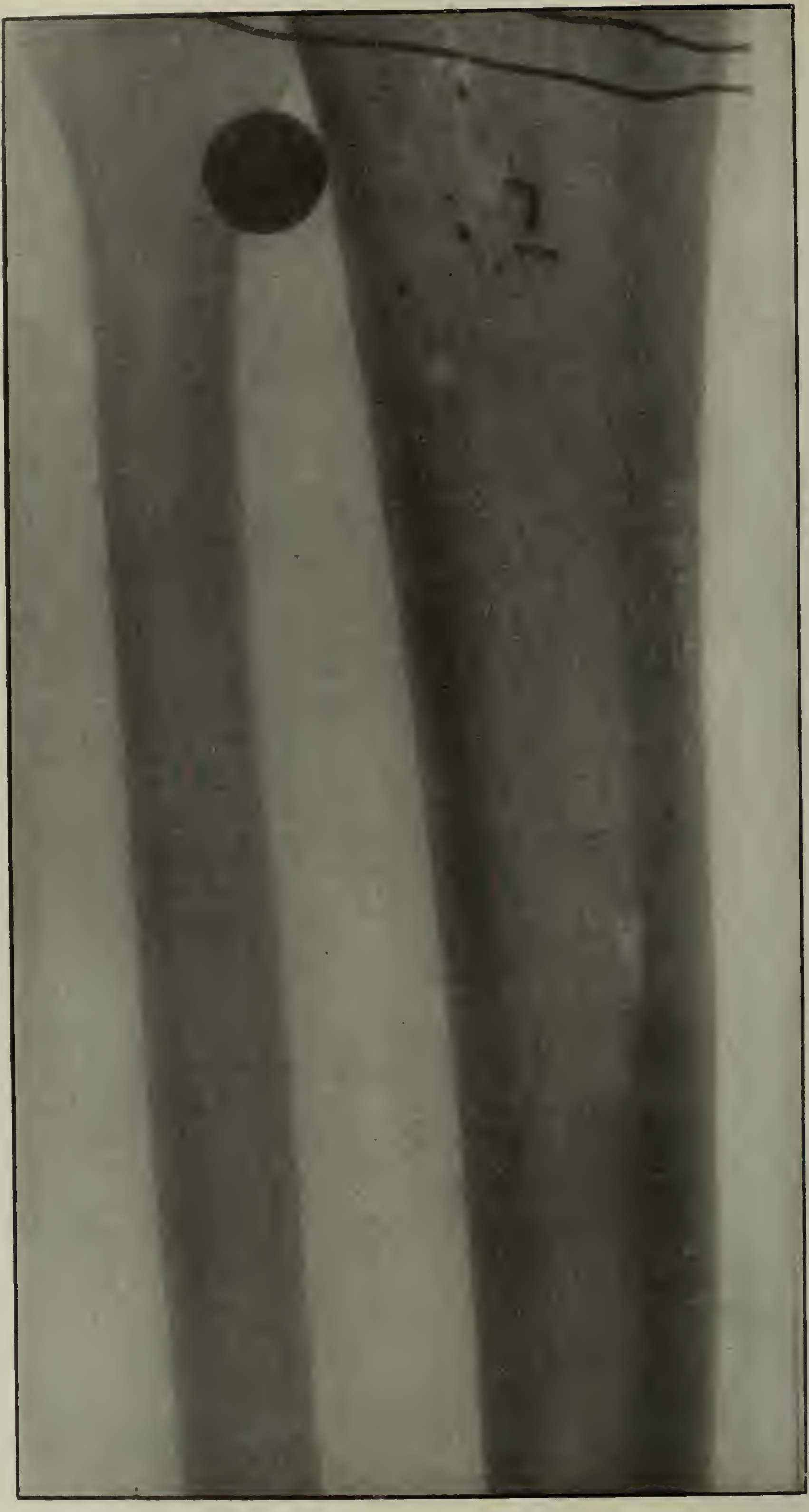
The outer tuberosity lay next to the photographic plate, with the knot in the localizing wire on the inside of the leg and farther away from the plate.

The line of projection is transversely through the tuberosities.

The shadow of the ball, as it is somewhat enlarged, not sharply defined, and of medium density, must lie about midway between the lines of the localizing wire or in the popliteal space just above and between the tuberosities, much nearer the popliteal surface than the bone. An accurate localization of the ball in a transverse line, however, would require an exposure of another plate in an antero-posterior line, but in this actual case the localization of the ball had to be made from this single plate, as only one exposure was made.

The ball struck the border of the popliteal space of the femur just above the tuberosity, without energy enough to cause a fracture, deform the ball, or even to leave, as a mark of contact, metal particles of the ball.

Plate 135.



SHRAPNEL—PLATE 135.

LOWER EXTREMITY.

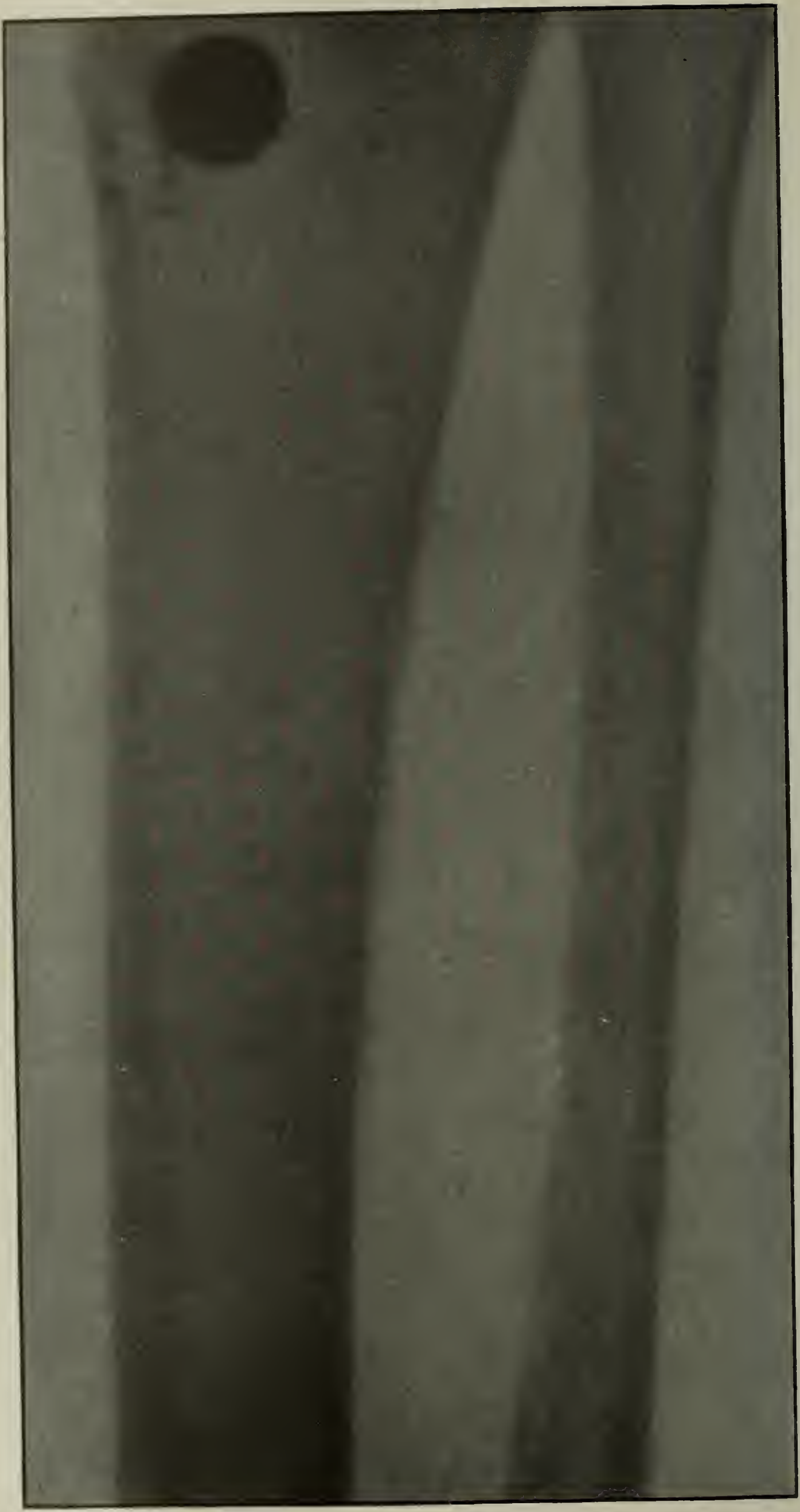
Gunshot Wound of the Left Leg, with Lodgment of the Missile.

The posterior surface of the leg lay next to the plate, as shown by the outline of the head of the fibula, but any estimate of distance from the plate, based on depth of the shadows, is of little value because there is no contrast between localizing-wire shadows in front of and behind the leg.

The slightly enlarged shadow of the ball indicates it to be farther from the plate than it would be if it lay behind the fibula. As the shadows of the metal fragments on the tibia are not sharp enough to indicate their position to be near the plate, the ball has lodged anteriorly between the tibia and fibula after ricocheting from the anterior surface of the tibia. The ball, being undeformed, struck the tibia with so little force that it barely penetrated the skin.

The reaction of infection in such wounds makes a diagnosis on physical examination difficult and indicates radiography.

Plate 136.



SHRAPNEL—PLATE 136.

LOWER EXTREMITY.

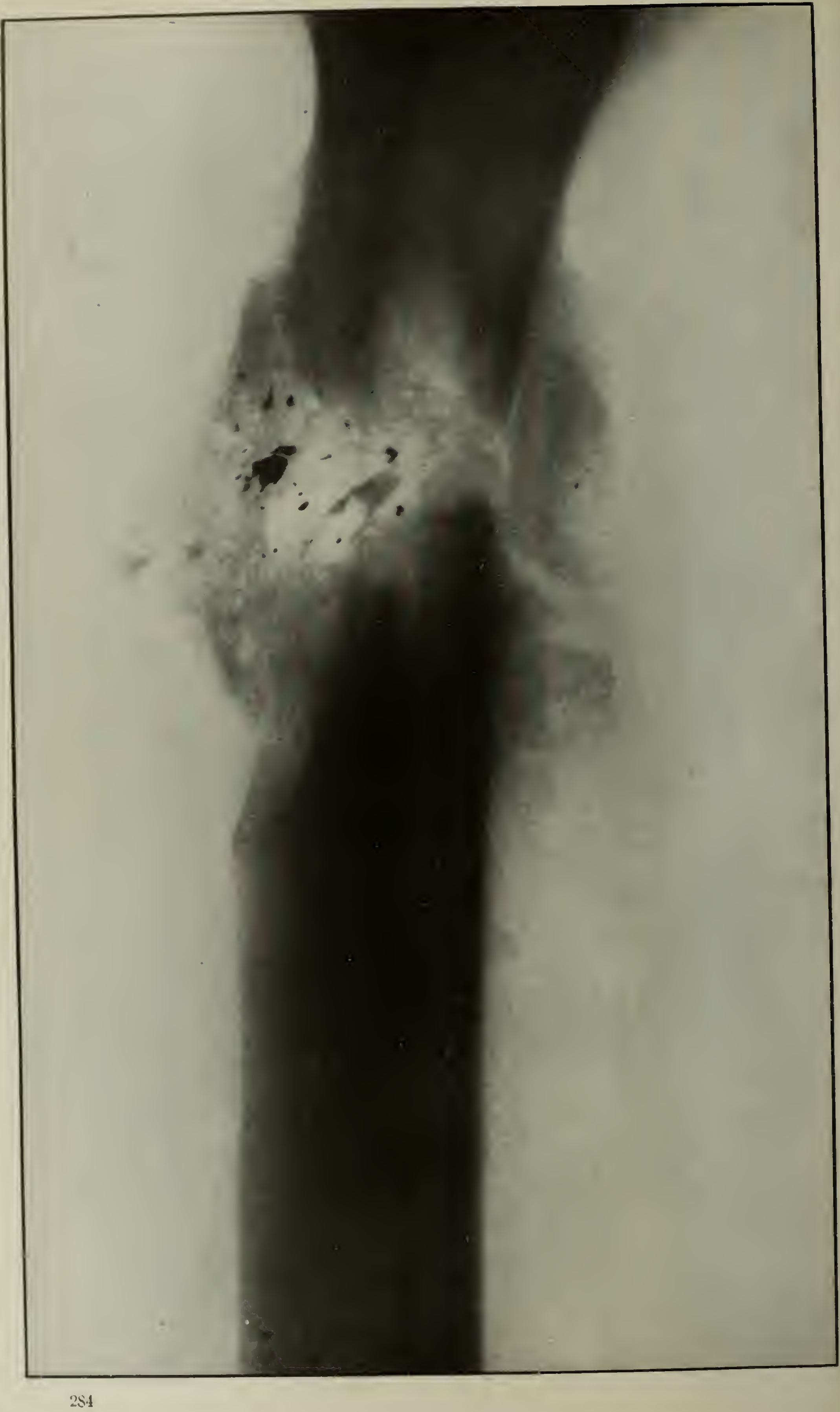
Gunshot Wound of the Leg, with Lodgment of the Missile.

The leg lay with its posterior surface next to the photographic plate. The enlarged shadow of the ball and the blurred outlines of the metal fragments require them to be some distance from the plate and therefore on the anterior surface of the tibia.

The impact has been from within outward with so little energy that the ball only touched the internal border of the tibia and lodged beneath the skin.

Without the reaction of inflammation and infection, diagnosis could be made by palpation, but extensive swelling indicates radiography.

Plate 137.



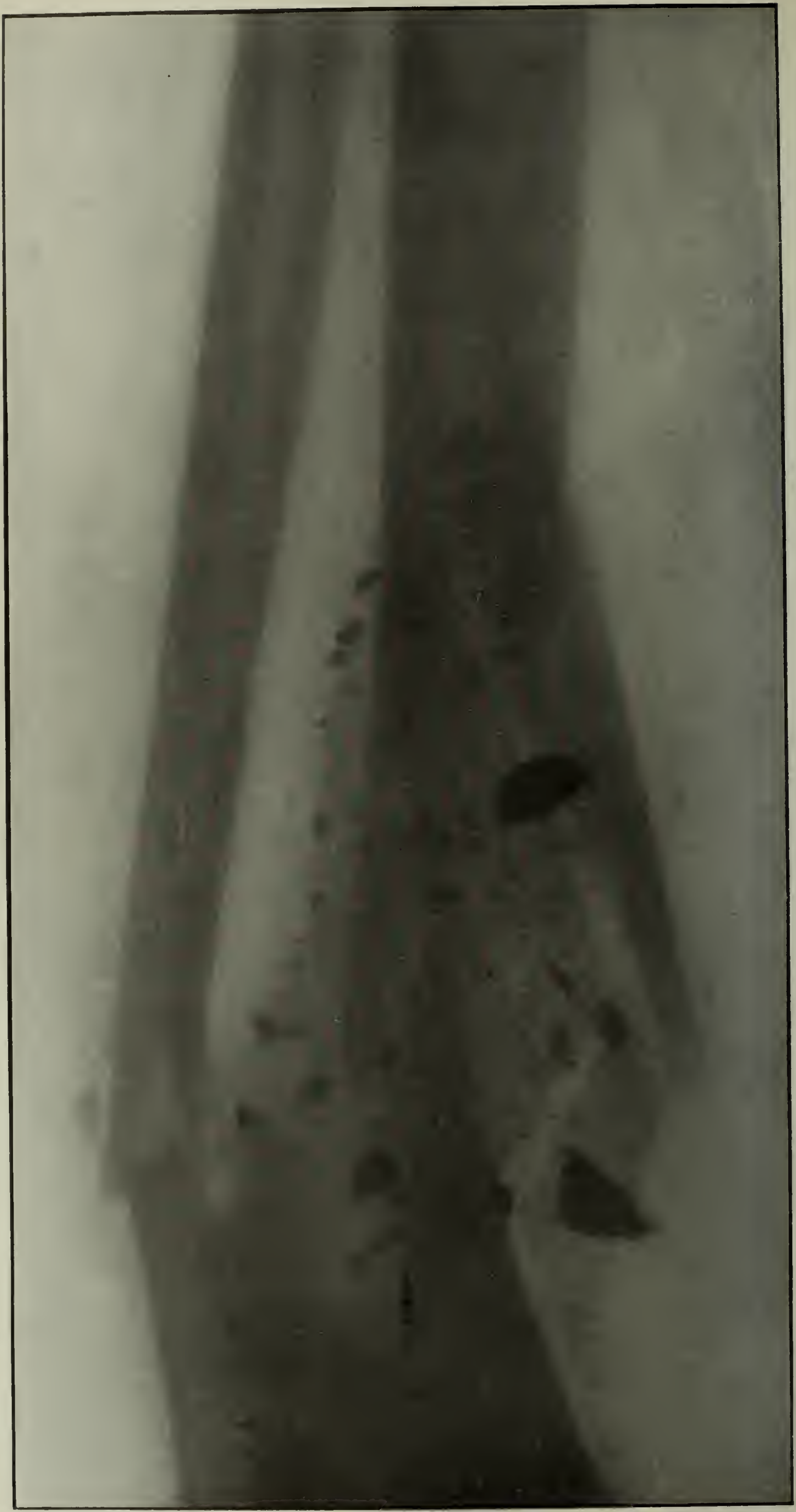
SHRAPNEL—PLATE 137.

LOWER EXTREMITY.

Gunshot Fracture of the Tibia and Fibula.

The fibular side of the leg lay next to the plate, as the distinct and not exaggerated outlines of the fibula can be seen in the dense shadow of the tibia. The wound, as indicated by the callous tissue, is shown in a state of repair, after the larger detached fragments of the fracture had been removed. The wound was caused by a missile carrying considerable energy. The small particles of metal marking the course of the missile show it was a shrapnel ball.

Plate 138.



SHRAPNEL—PLATE 138.

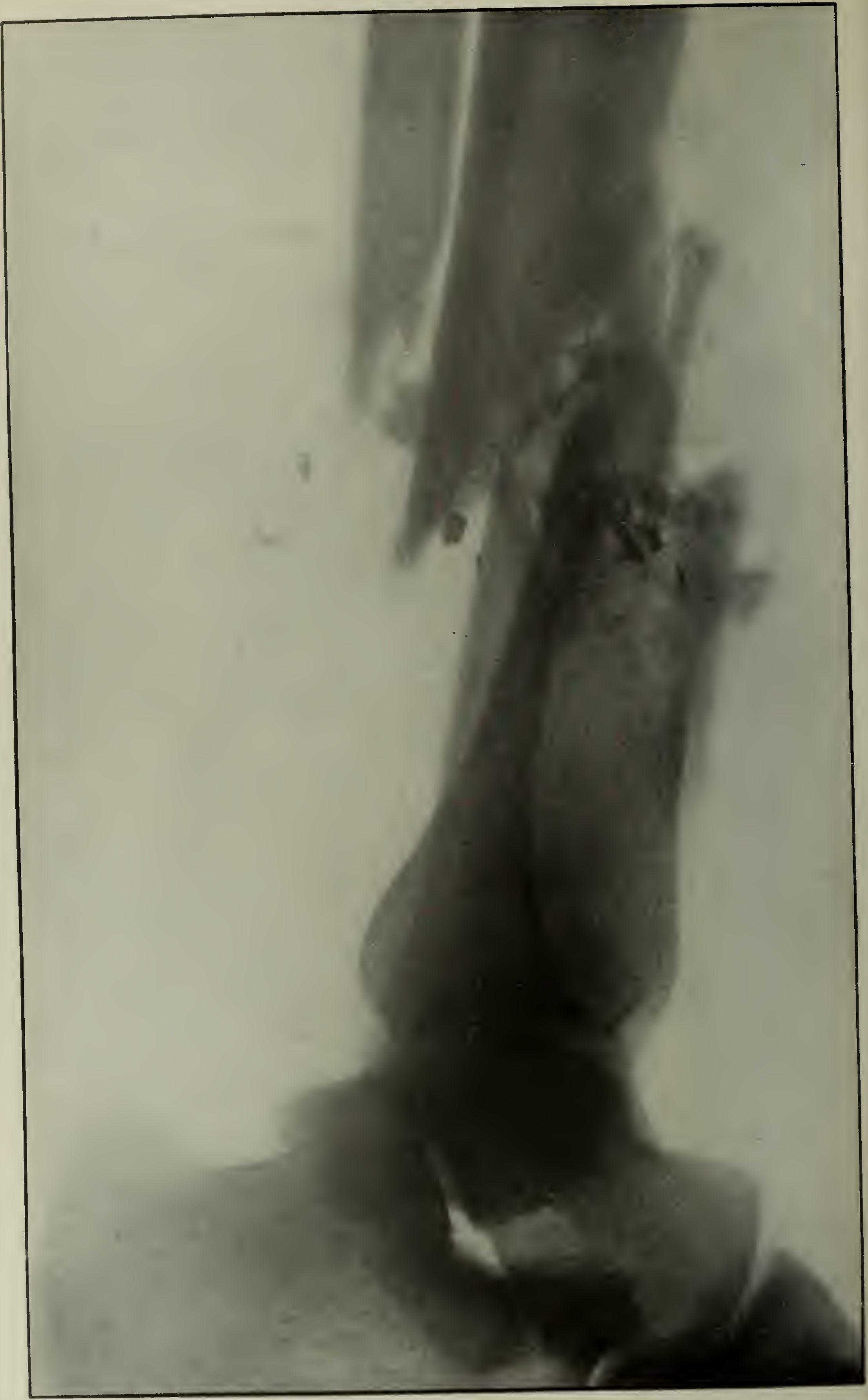
LOWER EXTREMITY.

Gunshot Fracture of the Right Tibia and Fibula.

This plate shows a type of wound caused by a number of fragments of a shrapnel ball or other similar missile. The missile was deformed by a near-by ricochet, from which large and small fragments struck simultaneously and distributed themselves over a large area. The larger fragments carried enough energy to fracture the bone by transmitting all of their energy in lodgment and by possibly breaking up into smaller fragments.

In this case the energy of the missile was transmitted to the tibia, with fracture and great fragmentation of the bone. The fracture of the tibia was secondary, resulting from indirect violence, due to the loss of the support of the tibia.

Plate 139.



SHRAPNEL—PLATE 139.

LOWER EXTREMITY.

Gunshot Fracture of the Right Tibia and Fibula.

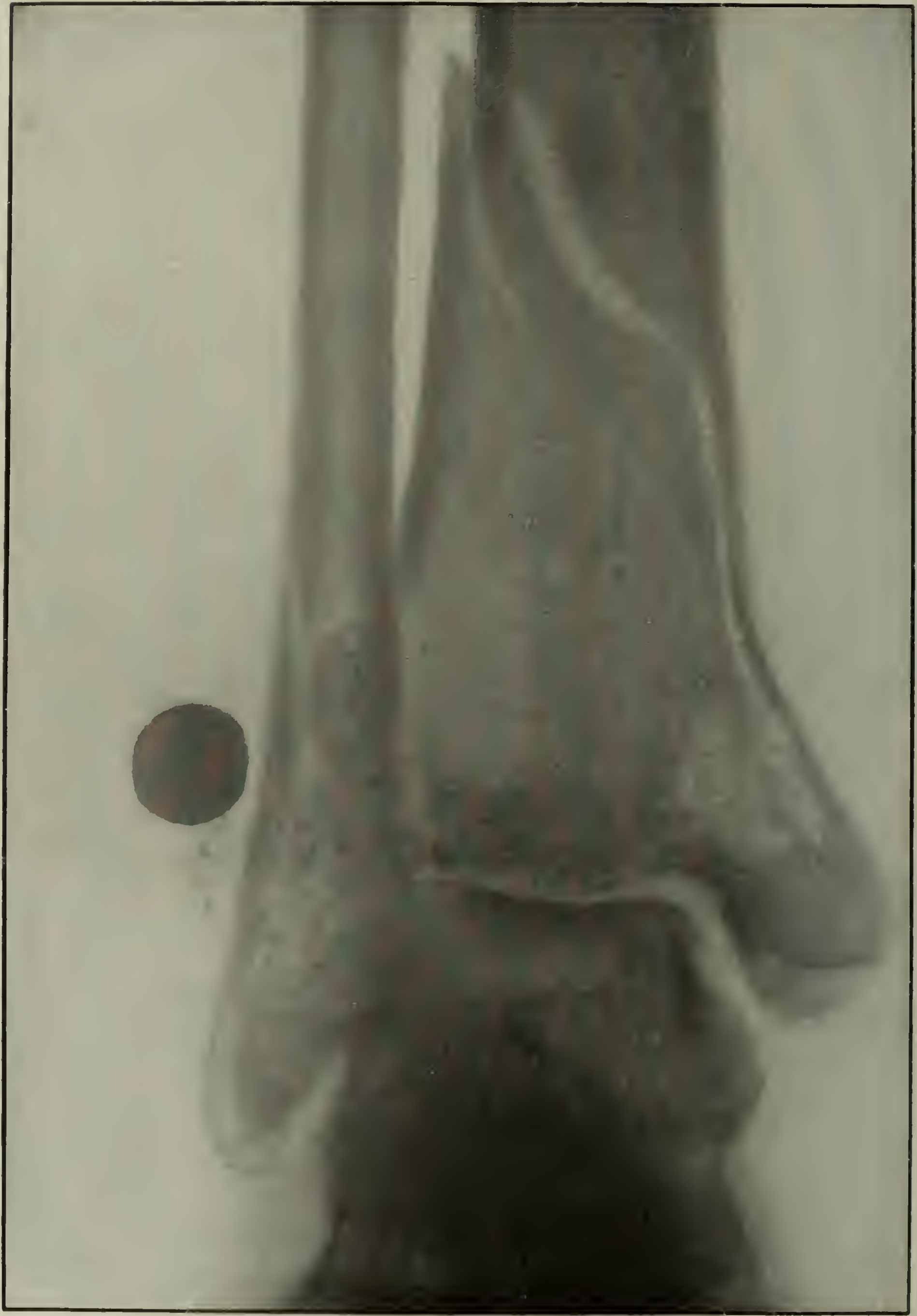
The course of the missile was from within outward and from before backward, striking both the fibula and the tibia, with fragmentation and displacement of both bones.

The fibula lay next to the plate, as indicated by its distinct normal shadow and the exaggerated outline of the internal malleolus.

The trail of metal fragments is typical of a shrapnel ball with the energy of high shrapnel velocity, but any lead missile without a protective jacket, under like conditions, might have produced the same effect.

The treatment is conservative until some positive indication arising in the course of an infection directs interference.

Plate 140.



SHRAPNEL—PLATE 140.

LOWER EXTREMITY.

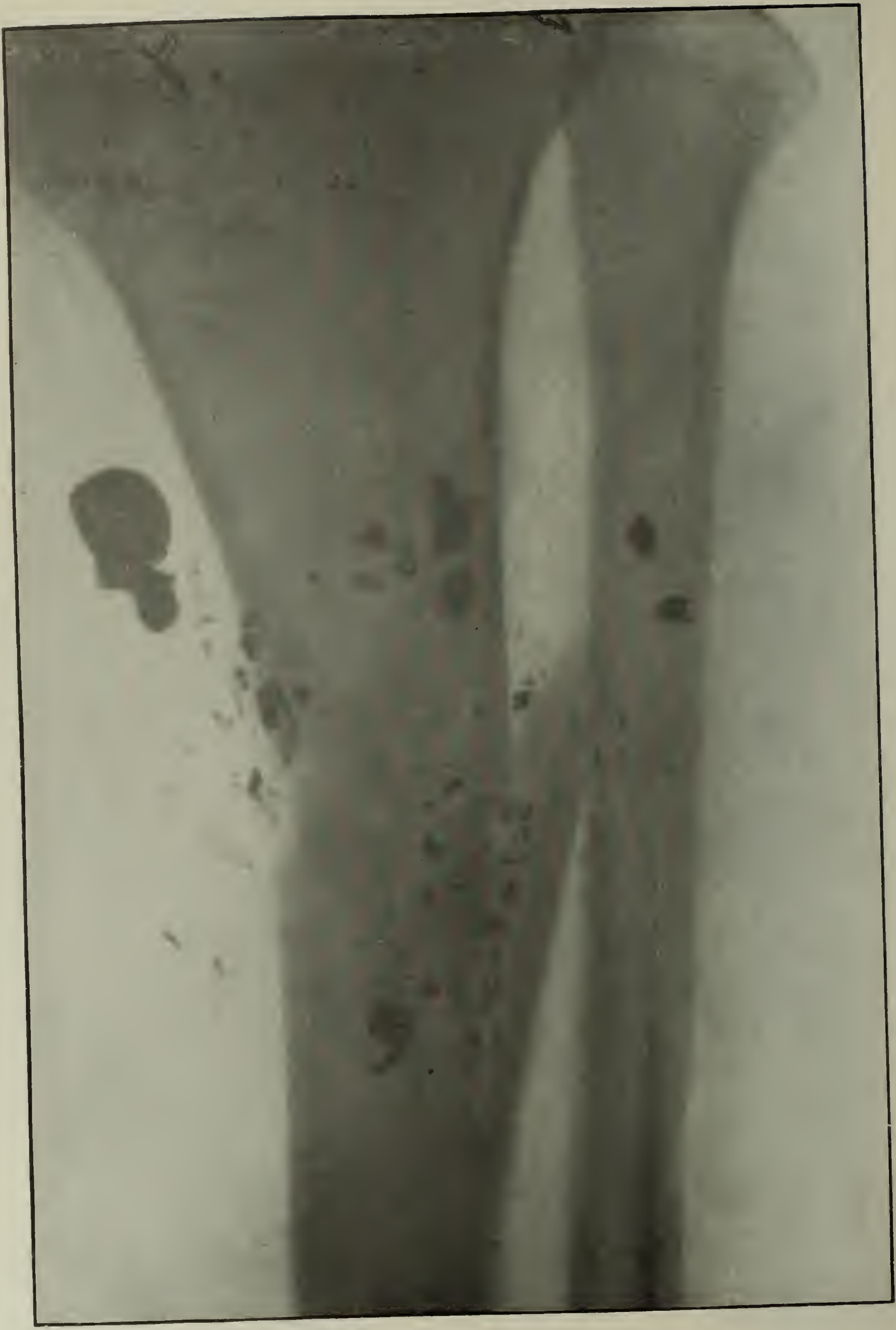
Gunshot Fracture of the Left Tibia and Fibula, with Lodgment of the Missile.

As the heel lay on the plate it is easy to identify the tibia and fibula of the left leg.

The course of the ball from the internal malleolus across to the lower end of the tibia and fibula is well marked by the trail of metal particles left by the contact of the ball with the bones. The indistinctness of the shadows of the lead particles and of the ball and the very slight enlargement of the ball indicates a contact with the anterior surface of the tibia and of the fibula with lodgment of the ball beneath the skin at the anterior border of the lower end of the fibula. The remaining energy of the missile was almost entirely spent on the tibia, causing a long oblique fracture, so that the contact with the fibula resulted in a crack only, without the separation of a fragment.

The treatment in such cases is conservative, with the subsequent removal of the ball from its superficial location.

Plate 141.



SHRAPNEL—PLATE 141.

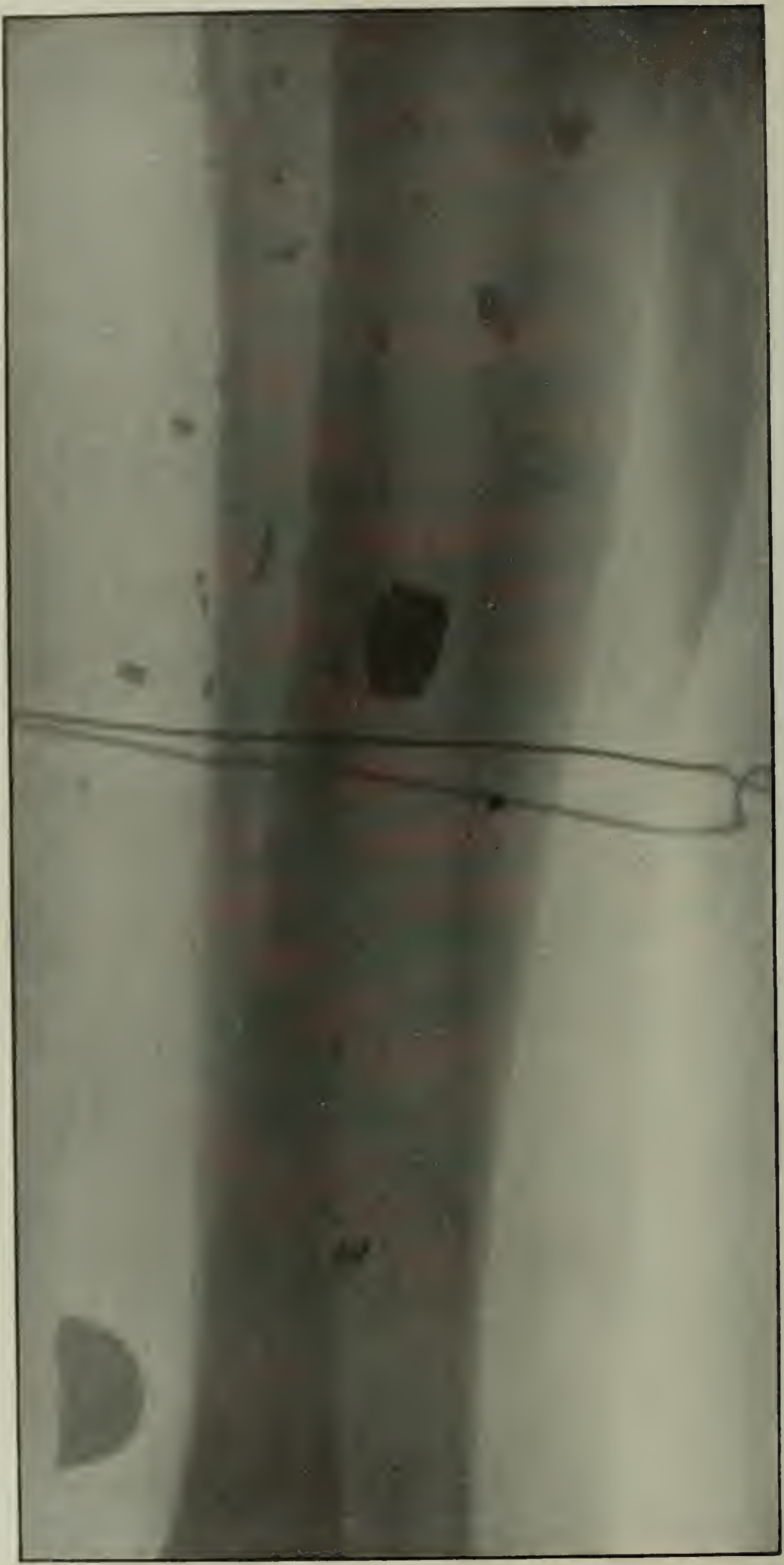
LOWER EXTREMITY.

Gunshot Fracture of the Left Tibia, with Lodgment of the Missile.

The course of the ball was from without and behind, ranging upward and inward, striking the tibia on the outer border, and causing a splitting fracture without displacement of fragments. The missile was most probably deformed by ricochet before it struck the bone, as there is too little bone injury to account for the spattering and wide distribution of the fragments by the direct impact of an undeformed ball. Two metallic fragments lying over the fibula were probably additional missiles detached from the ball as it ricocheted near the wound.

The treatment in such cases would be conservative, while meeting the indications of infection.

Plate 142.



SHRAPNEL—PLATE 142.

LOWER EXTREMITY.

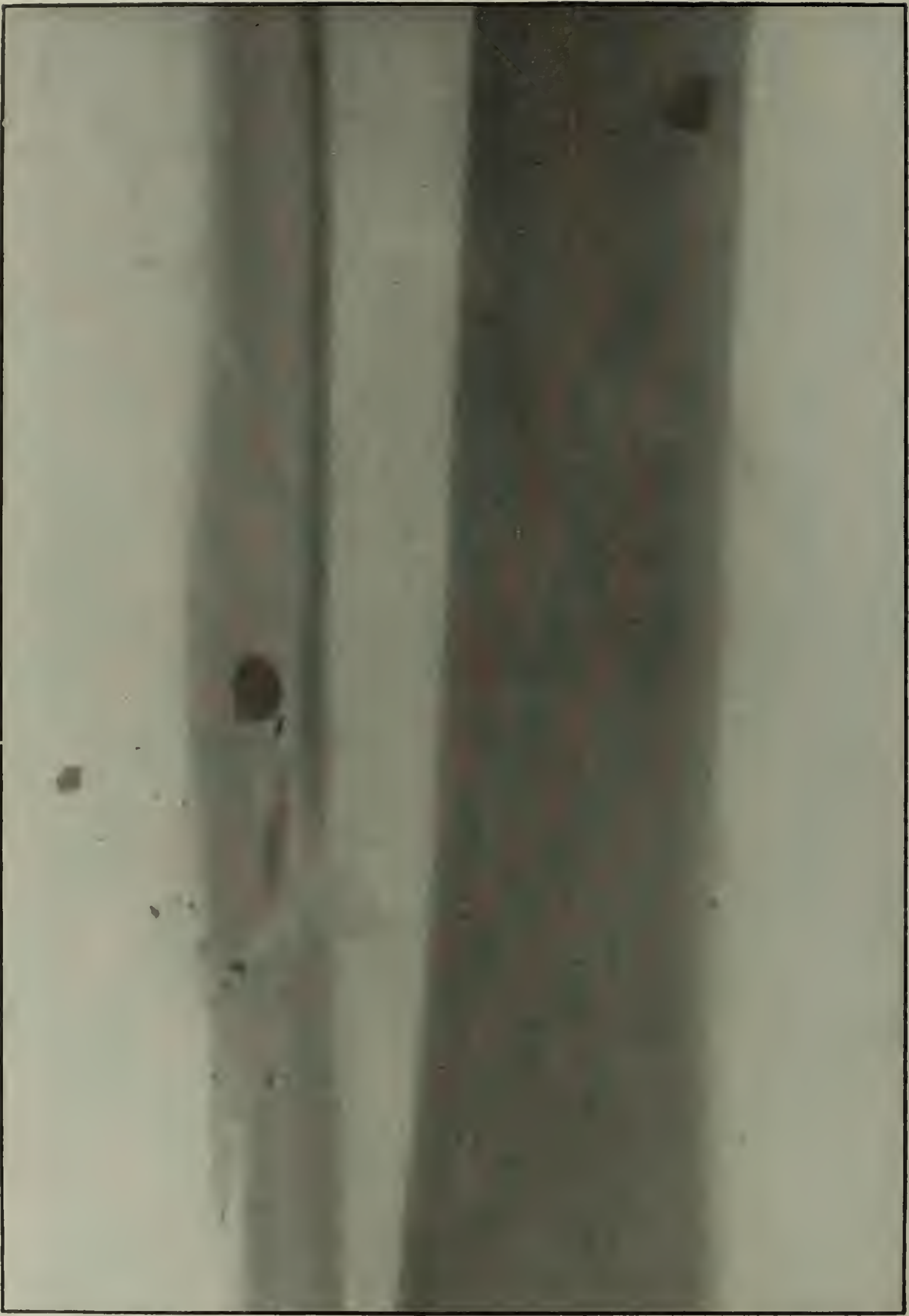
Gunshot Fracture of the Left Fibula, with Lodgment of the Missile.

This plate furnishes another example of the fragmentation of a shrapnel ball by ricochet on a near-by object before striking the body.

A slight fracture of the fibula is seen (at the top of the plate) with the lodgment of multiple missiles over a wide area, without other injury to the bones.

The fragments seen through the shadow of the tibia lie nearer the plate than the smaller fragments on the fibula. As the largest fragment, lying below, shows a much enlarged semicircular outline, its position is not close to the plate and it must lie superficially on the inner side of the leg.

Plate 143.



SHRAPNEL—PLATE 143.

LOWER EXTREMITY.

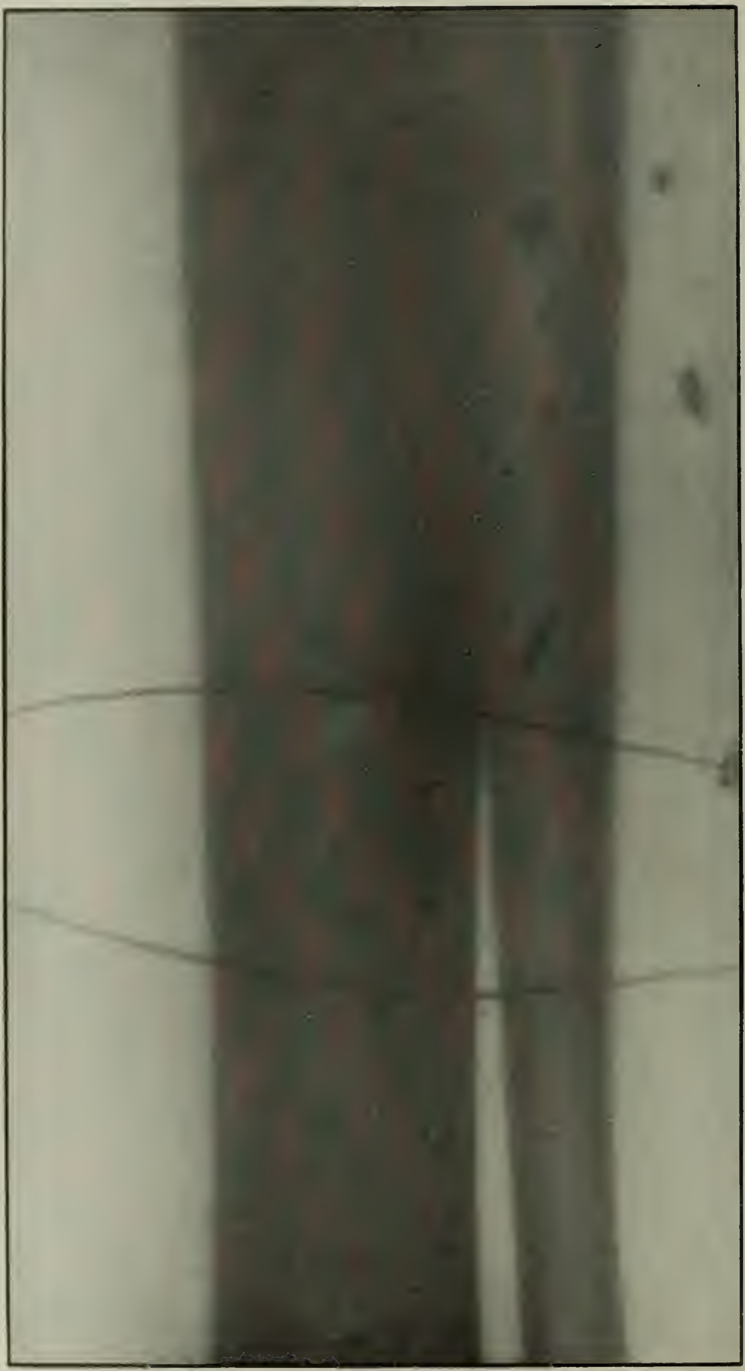
Gunshot Fracture of the Right Fibula.

This plate shows the right leg, because the calf always rests on the plate in the absence of a contraindication, which does not occur in this case, and because the slight angle of approach of the tibia and fibula identifies the relation of the lower end of these bones.

The nature of the fracture, without much fragmentation and with no displacements of fragments, indicates a slight striking energy of the missile, which was disintegrated by ricochet before striking the bone.

The fragments of a shrapnel ball, spattered on a near-by object, struck the leg in front over a wide area, as indicated by the fragments lying over the tibia and smaller ones lying on the inside of the bone. The larger metal fragment, on the fibula, is some distance from the plate, and probably lies in front of the bone, while the smaller ones, seen in sharper outline, lie behind.

Plate 144.



SHRAPNEL—PLATE 144.

LOWER EXTREMITY.

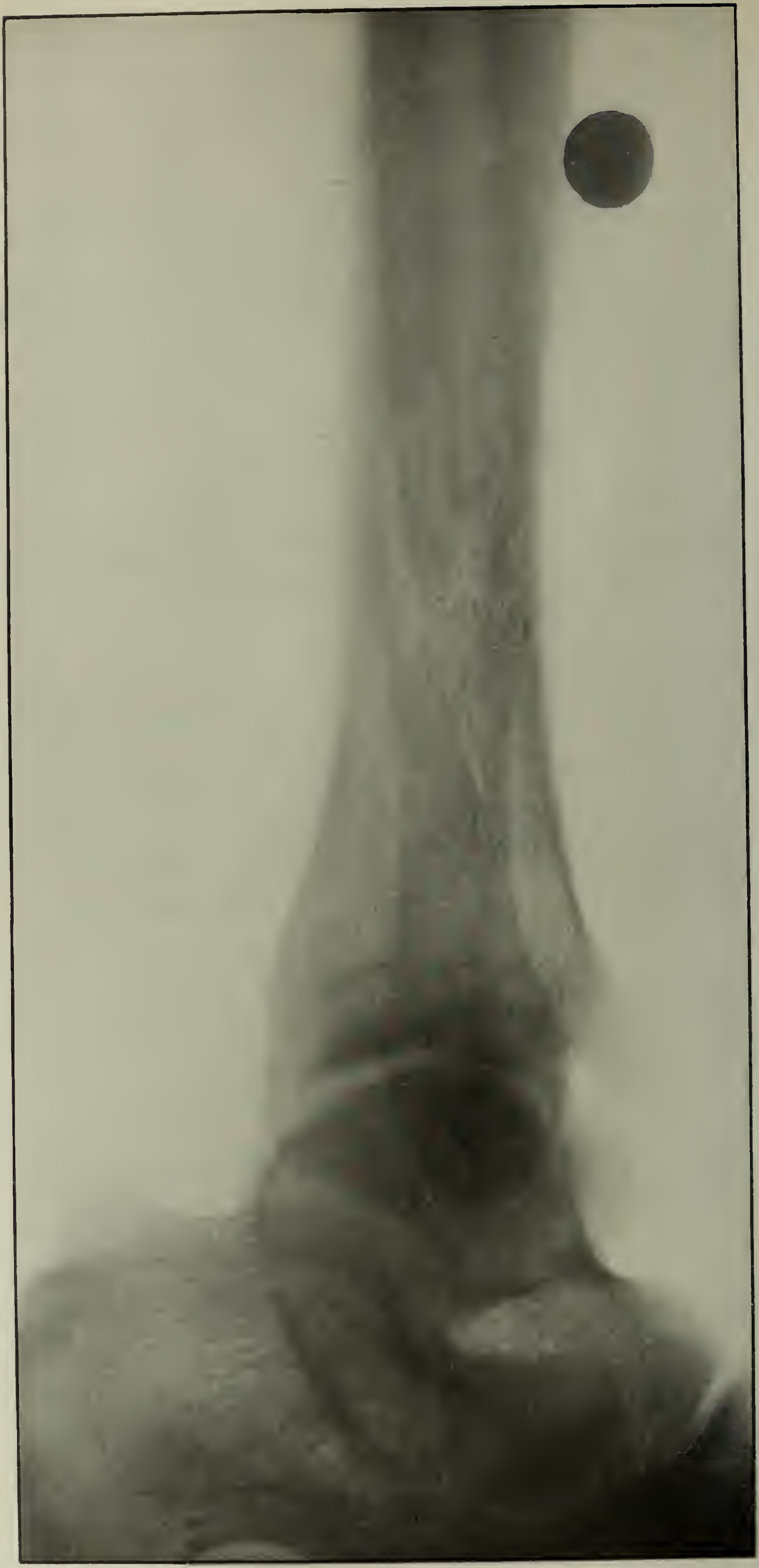
Gunshot Fracture of the Left Fibula.

This is another example of the condition, shown in plate 143, in which a shrapnel ball or similar missile is disintegrated by ricochet before affecting the wound.

By comparison of the shadows of the missiles with the shadows of the portion of the localizing wire lying nearer the plate (shown more deeply and distinctly), and with the portion lying in front of the leg, it can be concluded that the fragments lie superficially in front of the bones.

A slight fissure fracture of the fibula may be seen in the upper portion of the plate.

Plate 145.



SHRAPNEL—PLATE 145.

LOWER EXTREMITY.

Gunshot Fracture of the Fibula, with Lodgment of the Missile.

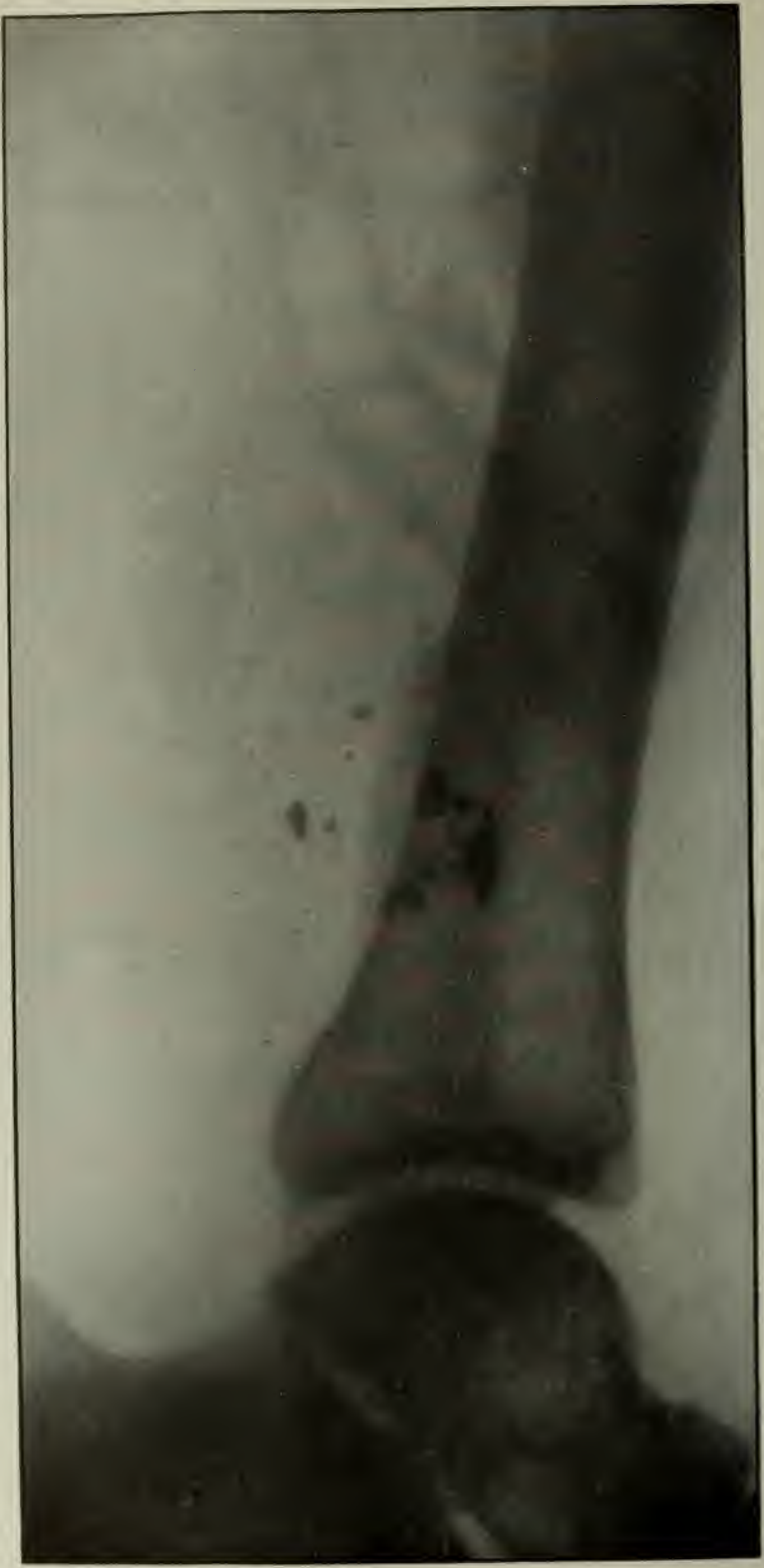
The fibular side of the leg lay next to the plate.

The sharp outline, great density, and normal size of the shadow of the shrapnel ball shows the ball almost in contact with the plate.

The metallic particles marking the contact of the ball and the fibula, at the seat of a diagonal fracture, without displacement of fragments, are shown so distinctly that they must also be near the plate.

The course of the ball, therefore, was from without, ranging inward and upward with the slight energy of long (shrapnel) range. The ball lies on the fibular side superficially, just in front of the fibula.

Plate 146.



SHRAPNEL—PLATE 146.

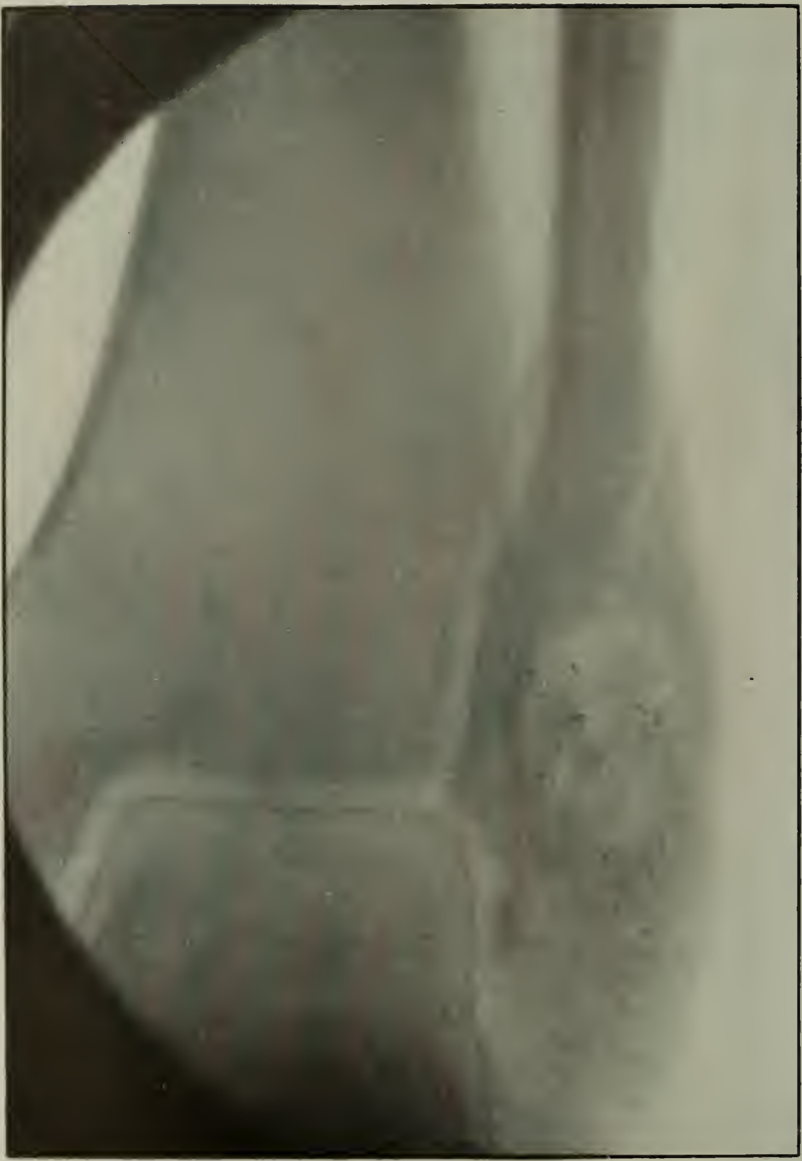
LOWER EXTREMITY.

Gunshot Fracture of the Right Fibula.

The plate exposed with the tibial side down shows the wound in the course of treatment, with a drainage tube in position after the detached fragments of several inches of the fibula have been removed on account of infection. Several fragments of the missile are shown on the lower fragment of the fibula.

Conservative treatment is evident and good results should follow.

Plate 147.



SHRAPNEL—PLATE 147.

LOWER EXTREMITY.

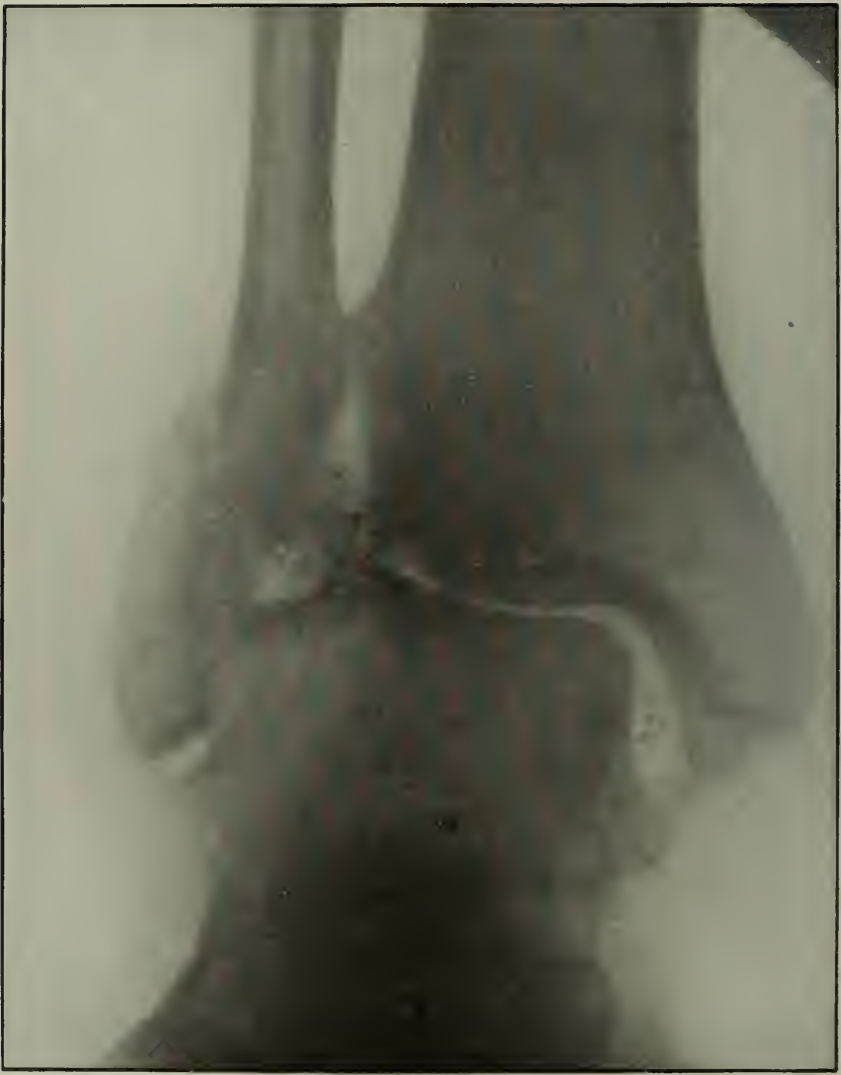
Gunshot Wound of the Lower End of the Right Fibula.

As the heel lay next to the photographic plate, the right ankle is easily identified. The clear shadows of even the very small metallic particles show them also next to the plate and, therefore, on the posterior surface of the external malleolus, where a shrapnel ball at extremely low velocity struck and produced a slight fracture, or more of a fissure, without separation of fragment.

The joint mortise is intact, as the line of fracture does not extend to the articular surface.

The shrapnel ball in such cases would lie just beneath the skin or escape through an adjacent wound.

Plate 148.



SHRAPNEL—PLATE 148.

LOWER EXTREMITY.

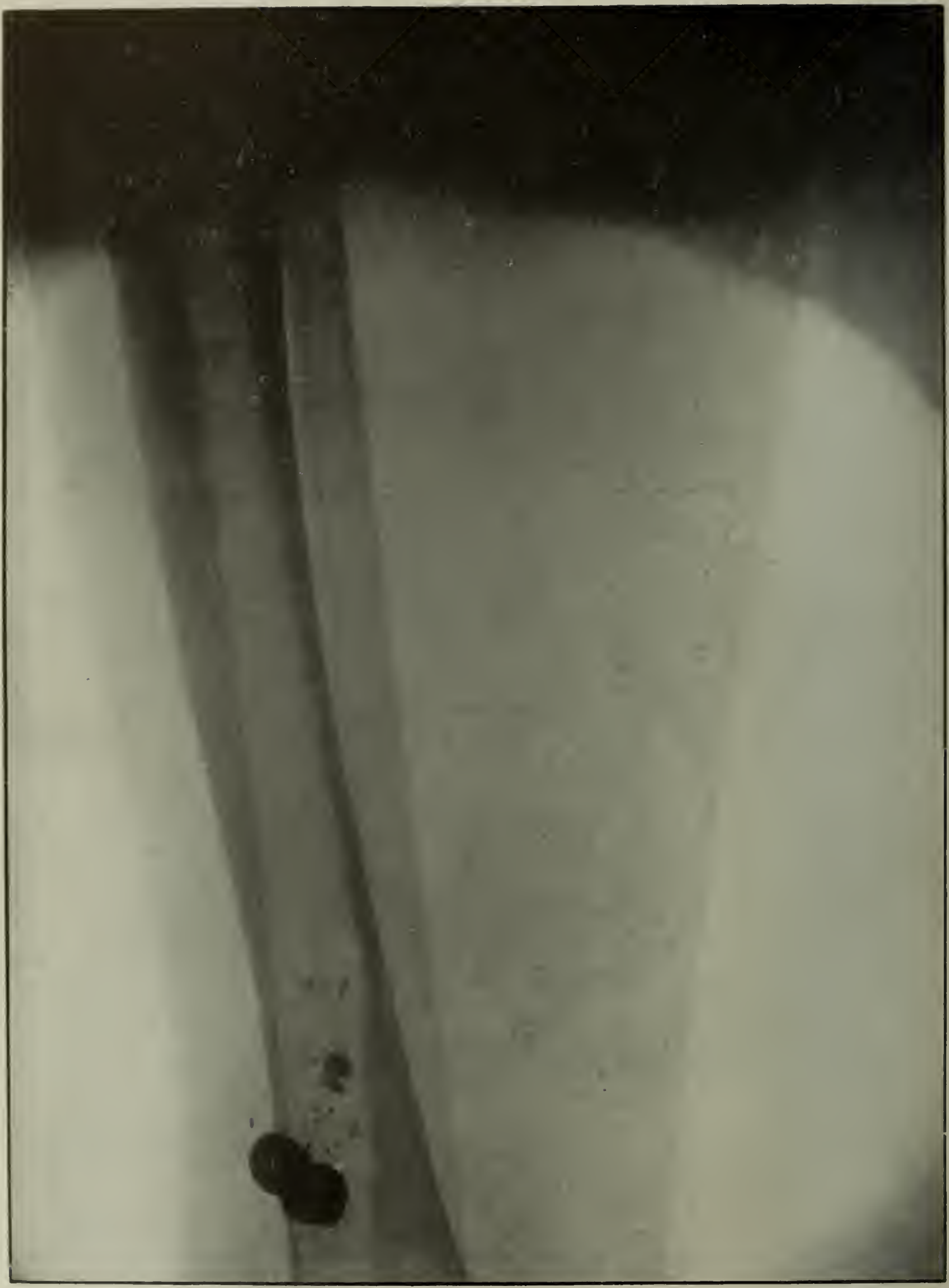
Gunshot (Pott's) Fracture of the Left Ankle.

As the heel lies next to the plate, the left ankle is easily identified. The course of the missile is shown by a metallic track from the internal to the external malleolus, and by a point of greater contact with the internal malleolus at the upper border of its articulation with the astragulus, resulting in an oblique fracture, separating the tip of the external malleolus.

At the point of first impact the posterior faciculus of the internal lateral ligament was severed. The missile therefore passed directly through the ankle joint, entering just behind the tip of the external malleolus, coursing over the posterior portion of the superior tibial articulation of the astragalus in front of the tendo Achillis to strike the upper articular surface of the external malleolus, with the resulting fracture. By this mechanism, the joint mortise has been widened by outward displacement of the external malleolus, while the rupture of the internal lateral ligament permitted the outward rotation of the astragulus, thus producing rather faithfully, by direct violence, a condition which might be called a "simulated Pott's fracture" of the first degree.

By the metallic path of the missile it is known that its soft metal mass was not protected by a hard metal jacket; by the slight damage done to the bone, which lay directly in its path, its velocity and consequent energy are revealed as very slight; by the absence of larger metallic fragments it is shown that the missile was not deformed nor robbed of its energy through ricochet; and as only these conditions can be furnished by a lead ball, undeformed and traveling at low velocity, the missile was a shrapnel ball.

Plate 149.



SHRAPNEL—PLATE 149.

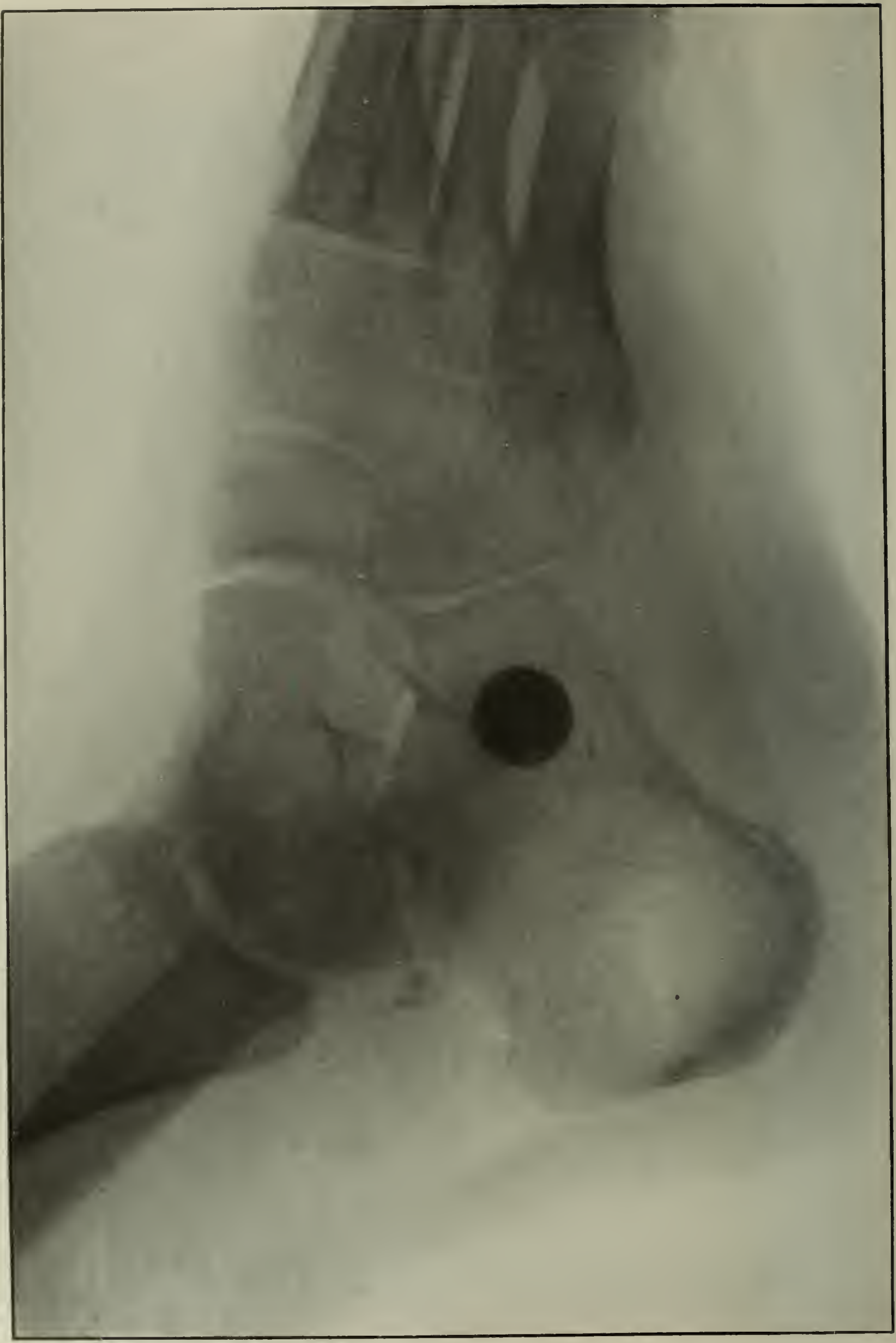
LOWER EXTREMITY.

Multiple Gunshot Wound of the Leg.

This plate exhibits the characteristic marking of the metal particles of a shrapnel ball scraped off by contact with the bone, showing the course of the ball in relation to the bone.

The evidence that two shrapnel balls struck the tibia without causing a fracture indicates that the velocity of shrapnel balls is, sometimes at least, very low and that this low velocity may occur at a comparatively short range from the point where the shrapnel balls are discharged from the chamber or near the apex of the "cone of dispersion." Such multiple wounds are caused before the balls have been so widely dispersed as when they arrive at the base of the "cone of dispersion."

Plate 150.



SHRAPNEL—PLATE 150.

LOWER EXTREMITY.

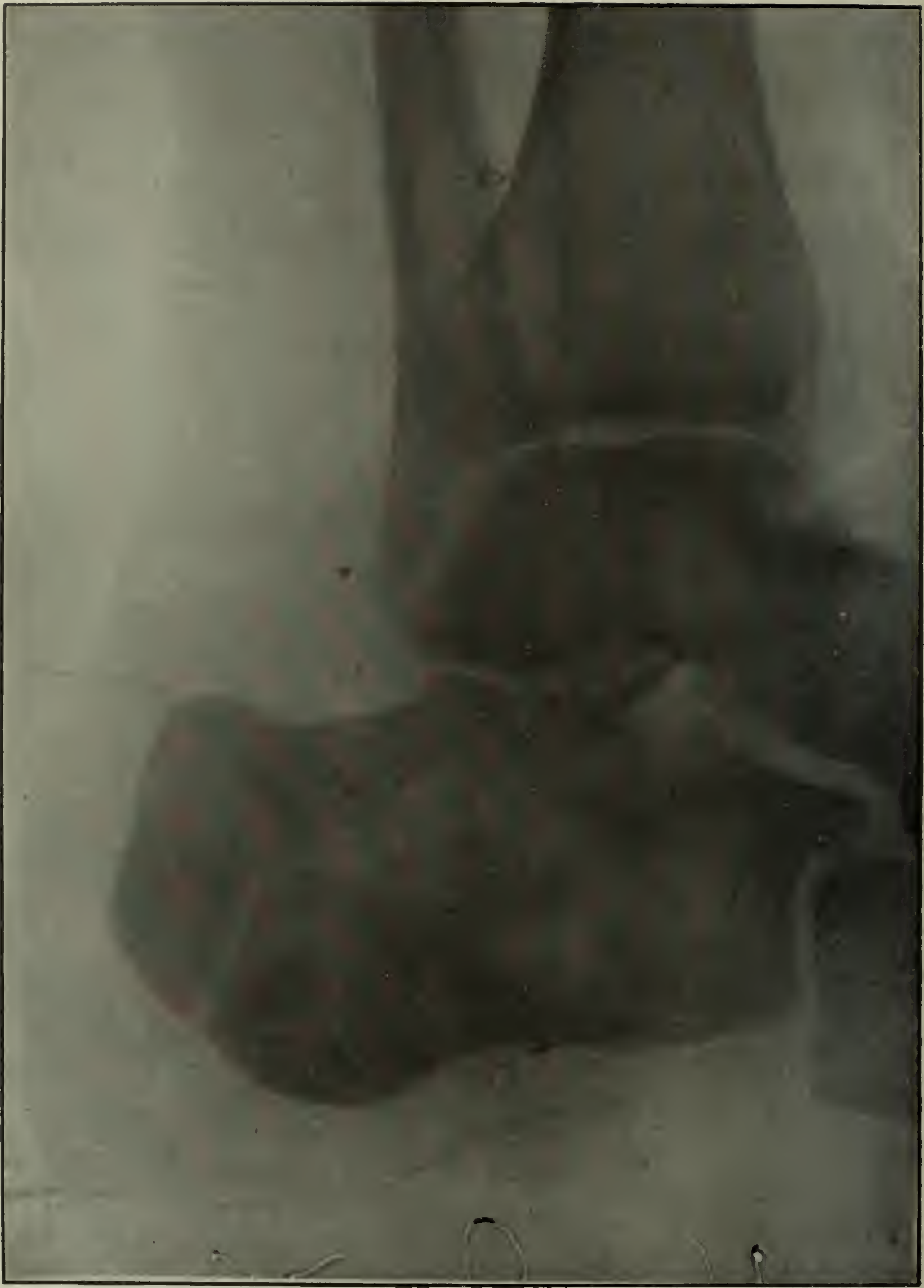
Gunshot Fracture of the Left Astragalus, with Lodgment of the Missile.

The external border of the foot lay next to the plate, as is shown by the articulation of the cuboid.

A fragment detached from the posterior inferior border of the astragalus and several small metal particles lying behind the fragment are in evidence.

The enlarged shadow of the ball indicates that it does not lie close to the plate, and it must then lie at least as far away as the internal surface of the calcaneus and at a depth from the sole that can be measured on the plate.

Plate 151.



SHRAPNEL—PLATE 151.

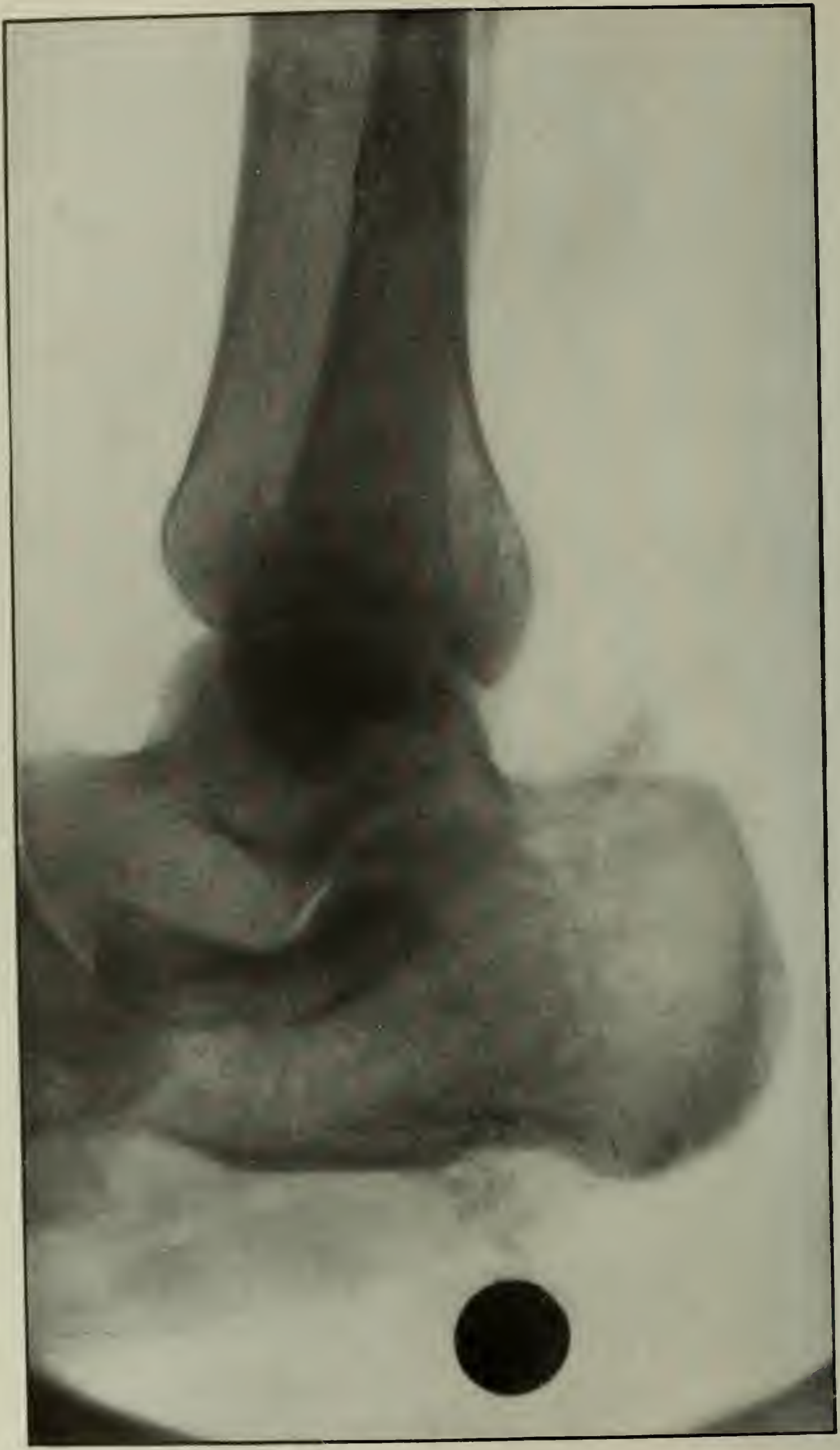
LOWER EXTREMITY.

Gunshot Fracture of Left Calcaneus.

The fibular side lay next to the plate, as shown by the shadow of the fibula and the calcaneo-cuboid articulation.

As the metallic particles, showing the path of the missile, appear to be next to the plate, the course of the missile was from the external border of the tendo Achillis diagonally downward and forward, causing only a slight fissure of the calcaneus. A missile, to have done so little damage and to have left a metallic track showing its contact with the bone, must have been unjacketed and of low velocity, and therefore a shrapnel ball.

Plate 152.



SHRAPNEL—PLATE 152.

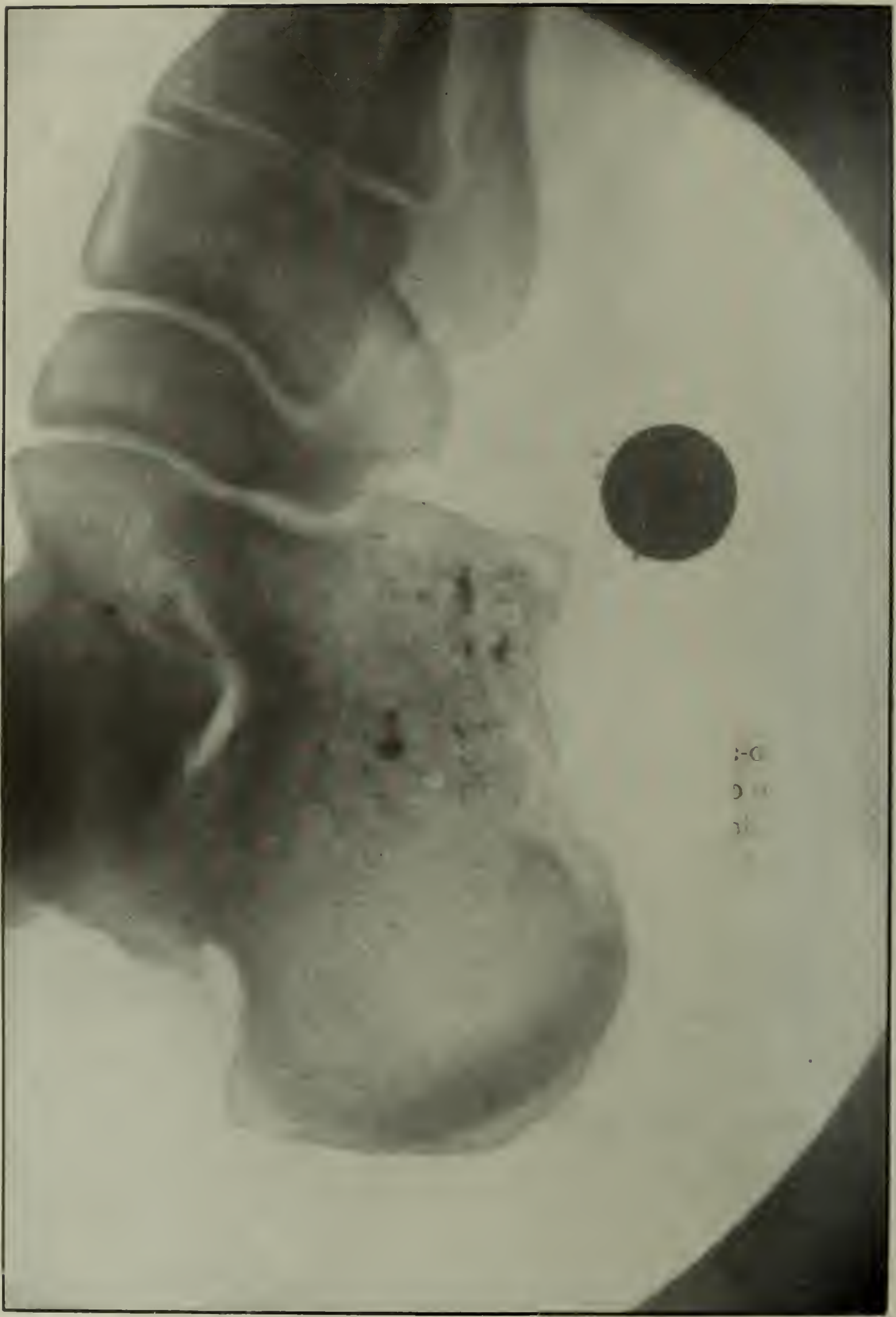
LOWER EXTREMITY.

Gunshot Wound of the Heel, with Lodgment of the Missile.

The tibial side of the foot lay next to the photographic plate.

The normal size, great density, and sharp outline of the shadow of the shrapnel ball show that it lay also close to the plate and about an inch below the inside of the body of the calcaneus. No metallic particles mark the track of the ball in this case, because the course was parallel to the inner surface of the bursa without forceful, or perhaps any, contact with the bursa, and passing through soft tissue only.

Plate 153.



SHRAPNEL—PLATE 153.

LOWER EXTREMITY.

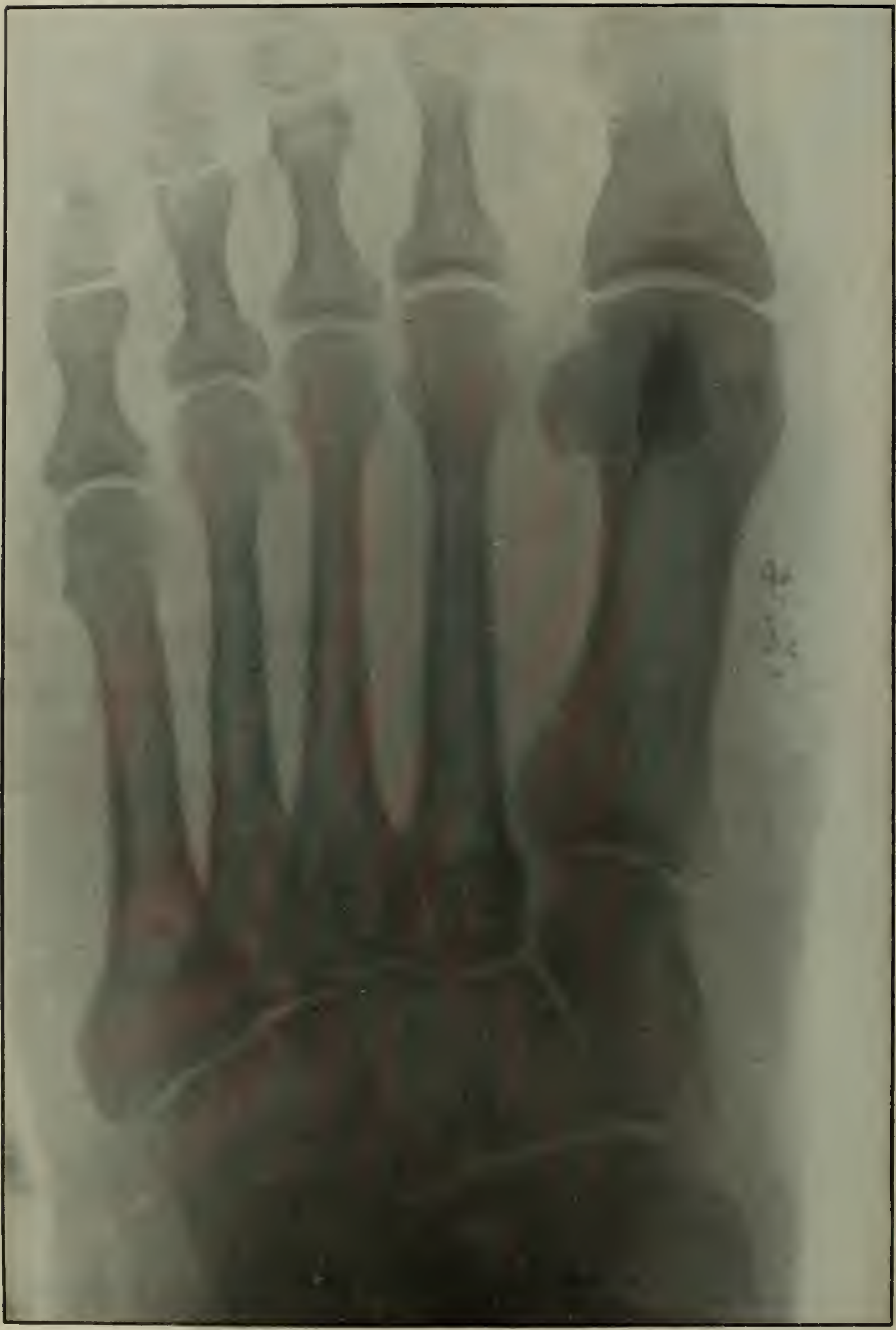
Gunshot Wound of the Heel, with Lodgment of the Missile.

That the inner border of the foot lay next to the plate is shown by the articulation between astragalus, scaphoid, internal cuneiform, and first metatarsal.

The metallic particles show the course of the ball from the posterior calcaneo-astragaloid ligament to below the anterior inferior border of the calcaneus.

As the shadow of the ball is enlarged and the shadow of the fragments blurred, their position is not near the plate and their location is therefore on the external plane of the calcaneus, with the ball lying near the sole.

Plate 154.



SHRAPNEL—PLATE 154.

LOWER EXTREMITY.

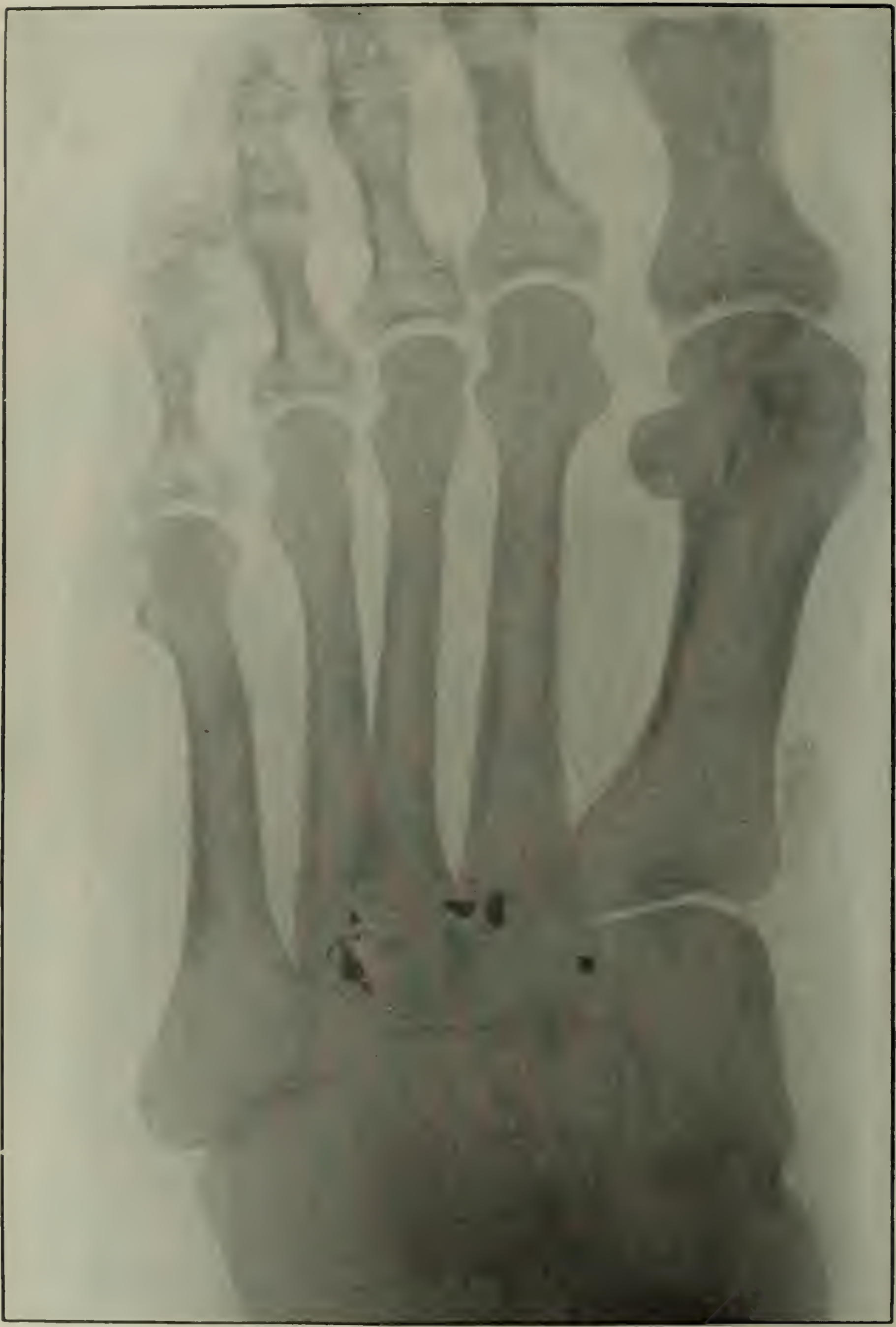
Gunshot Wound of the Foot.

The plate shows, in the wound of entrance, the metal particles deposited by a shrapnel ball which passed out of the sole of the foot without damage to the bone.

The missile carried some small particles of lead, almost wholly detached by a ricochet before striking the foot, which were scraped off as it passed through the skin.

The wound was infected, and radiography was indicated for diagnosis.

Plate 155.



SHRAPNEL—PLATE 155.

LOWER EXTREMITY.

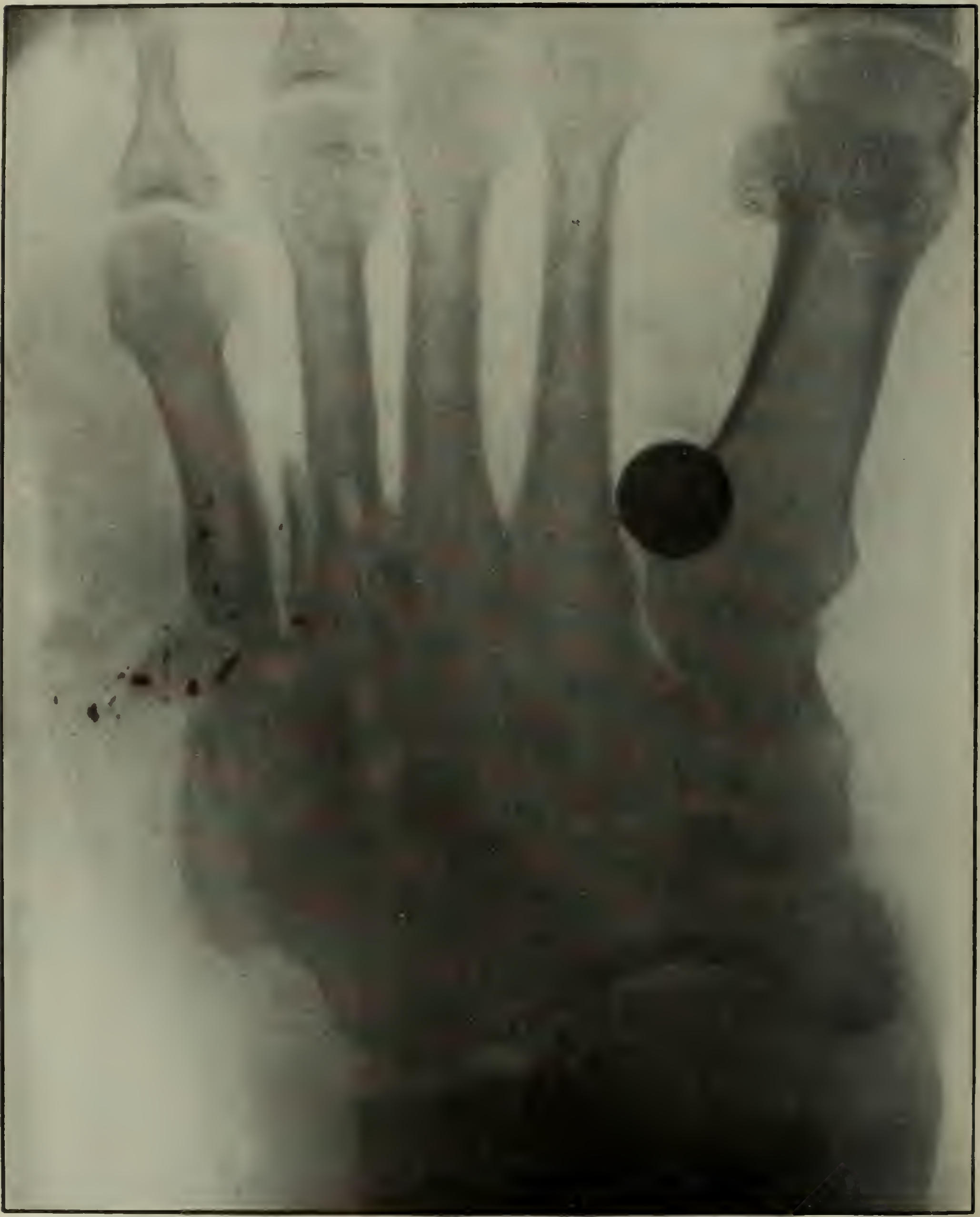
Gunshot Wound of the Foot.

The sole of the foot lay next to the plate.

While the very clear, sharp outlines of the metal fragments would seem to show them very near the plate and consequently at the platen side of the tarsus, the foot is not of sufficient thickness to make a very appreciable difference between shadows of such fragments on the dorsal and on the plantar surfaces of the metatarsus. It is very probable that the ball struck the convex, rather than the concave outline of the transverse arch, as the missile has escaped with no fracture of the bones, which would have been very difficult in mechanical accomplishment if its course had been along the convex outline.

There is no fracture of the bones, although a shrapnel ball has passed transversely through the foot, striking the heads of the second and third metatarsals with only slight injury and leaving a few metal particles at points of contact.

Plate 156.



SHRAPNEL—PLATE 156.

LOWER EXTREMITY.

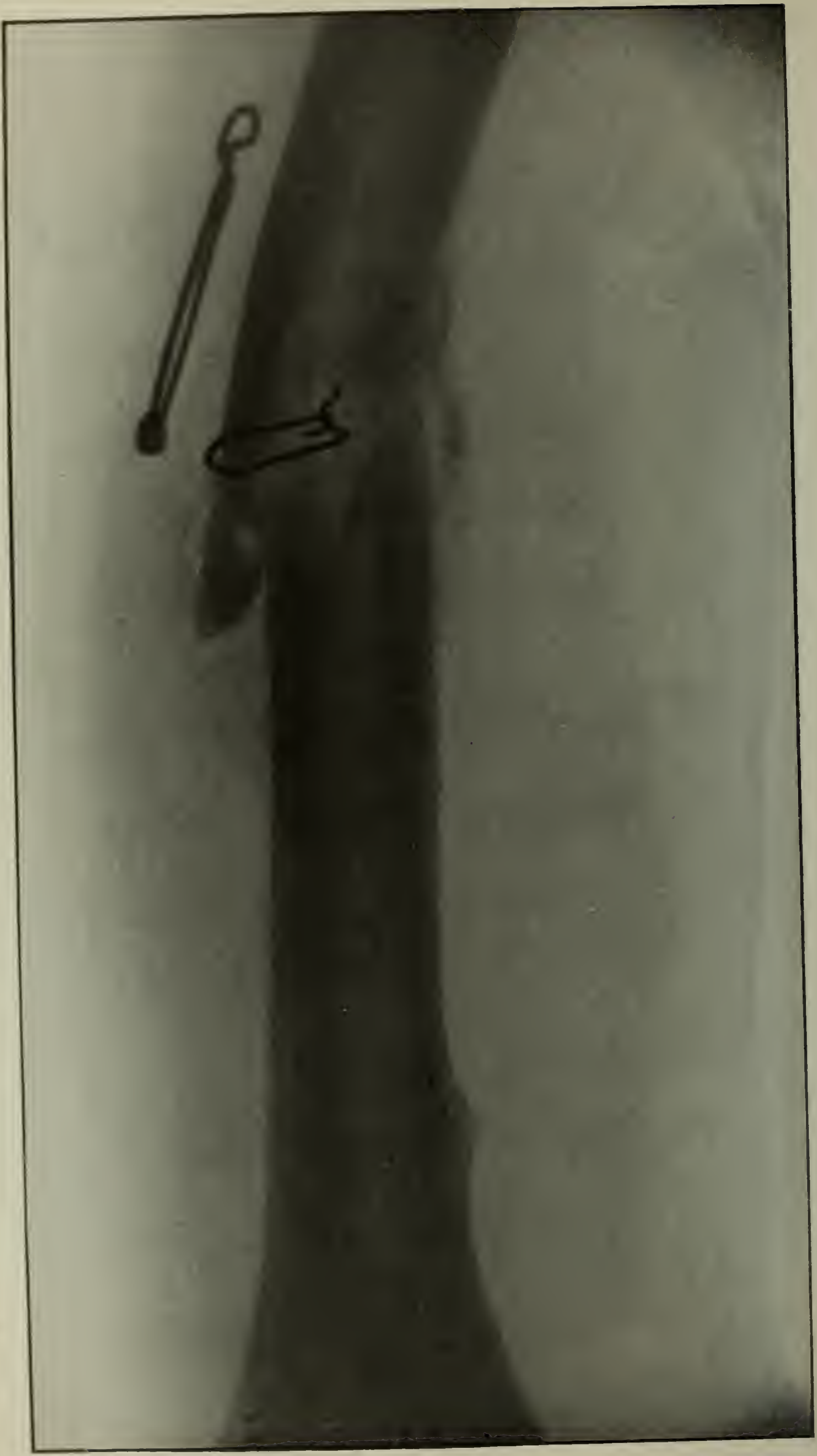
Gunshot Wound of the Left Foot by Multiple Missiles, Fracture of the Metatarsus, and Lodgment of the Missile.

The sole of the foot lay next to the plate.

The normal outline of the shadow of the shrapnel ball shows it to lie near the plate or at least beneath the plantar surface of the first metatarsal. The fragments of metal lying near the fourth and fifth metatarsals lie either in the same relation or on the planter side of the metatarsus. The metallic track leads to the wound of exit of shrapnel ball, other than the one lodged.

Even though the missile has escaped, its identity can be creditably established by the one remaining, which, it is morally certain. was the escaped missile's companion. These shrapnel particles again demonstrate that the metal deposits seen in other wounds can be identified as particles of lead scraped off from shrapnel balls in the contact of the latter with bones.

Plate 157.



OPERATIVE INTERFERENCE IN GUNSHOT WOUNDS.

In the 1,500 radiograph plates from which this collection was selected, only four were found showing operative interference for the repair of fractures.

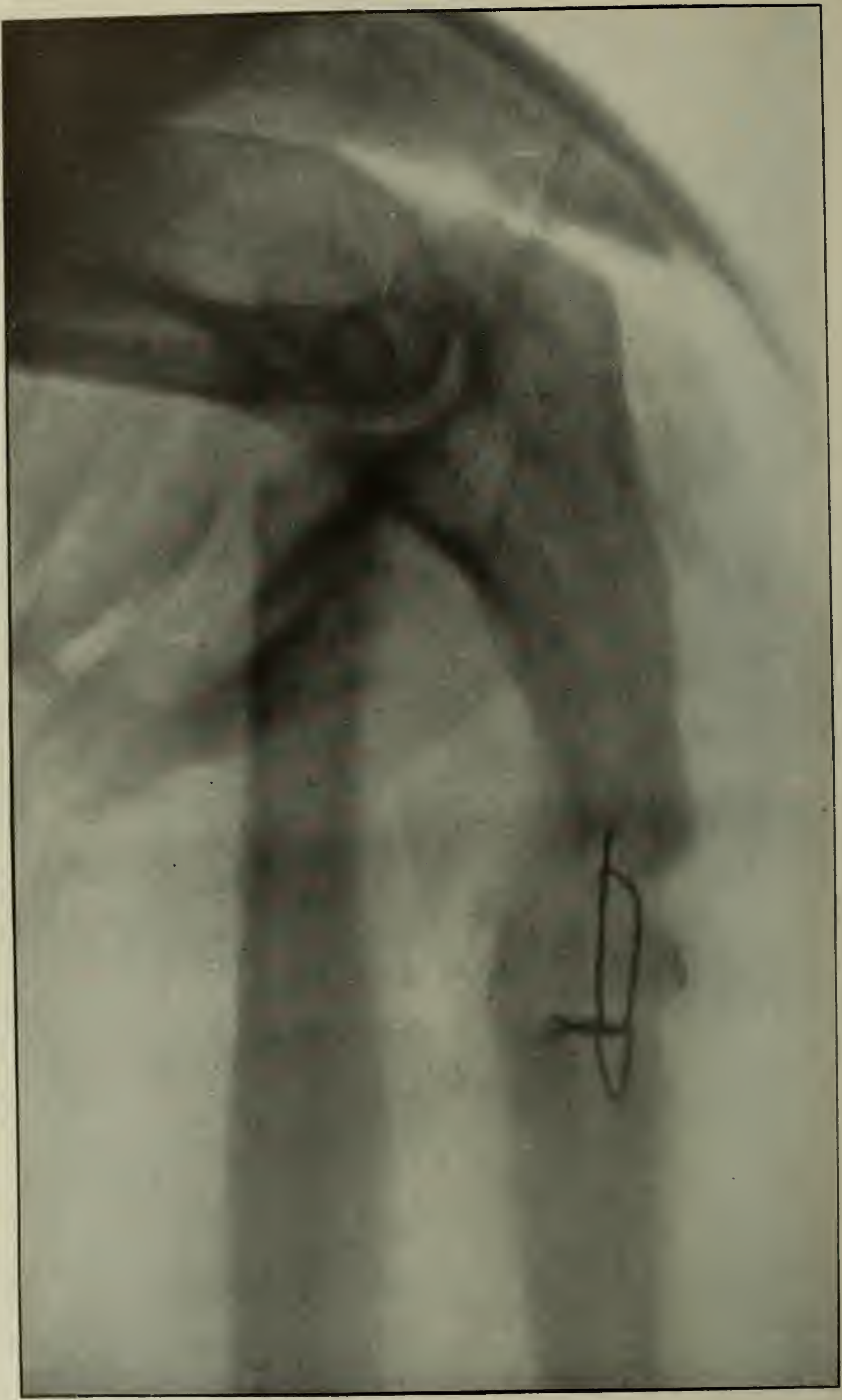
While no data are available from which to determine accurately the ratio of these operations to the entire number of fracture cases under treatment, and as, most certainly, there were some formal amputations, excisions, immediate immobilization of fractures, and other operative procedures which were not submitted to radiography, it may nevertheless be justly inferred from this radiographic evidence that very few such operations were performed.

OPERATIONS—PLATE 157.

Gunshot Fracture of the Humerus.

This plate shows an attempt to wire a fracture of the humerus, which, very probably, would have recovered as favorably without interference.

Plate 158.

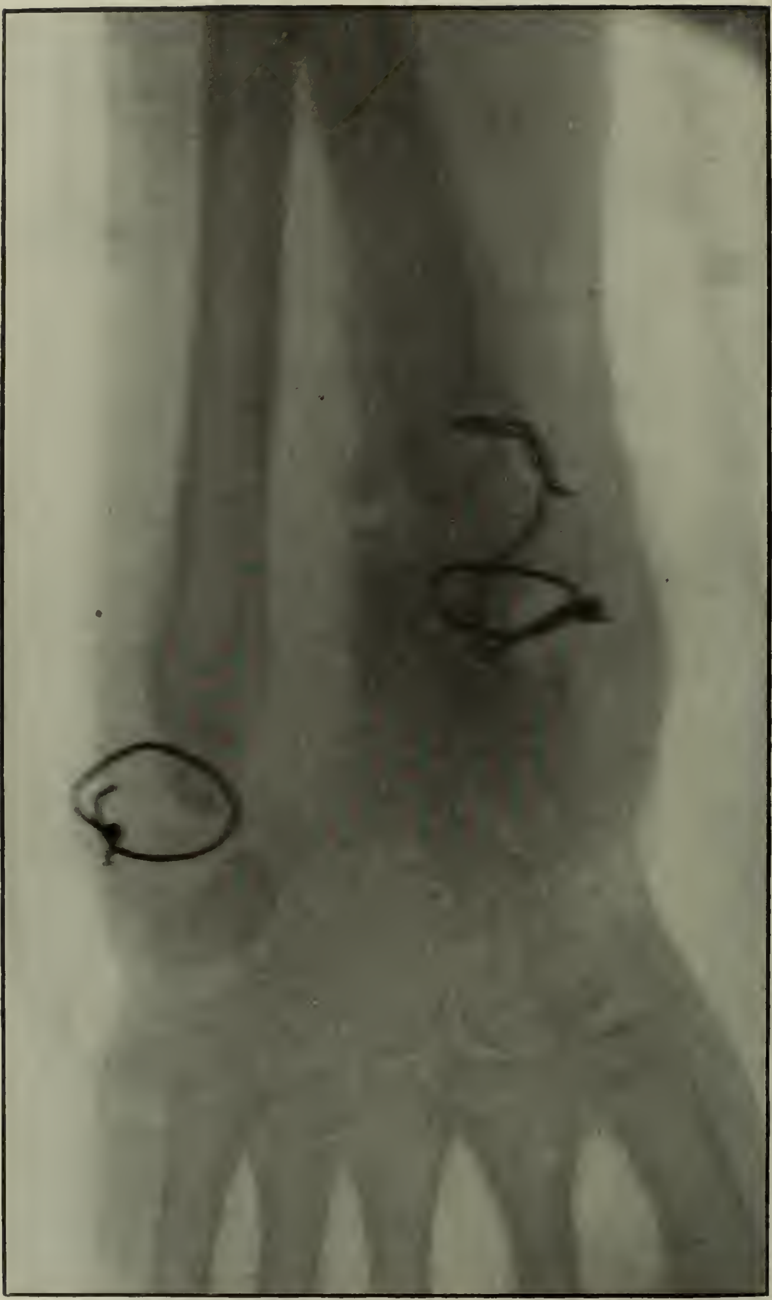


OPERATIONS—PLATE 158.

Gunshot Fracture of the Ulna.

This plate shows an attempt to wire the ulna in a clean wound.

Plate 159.

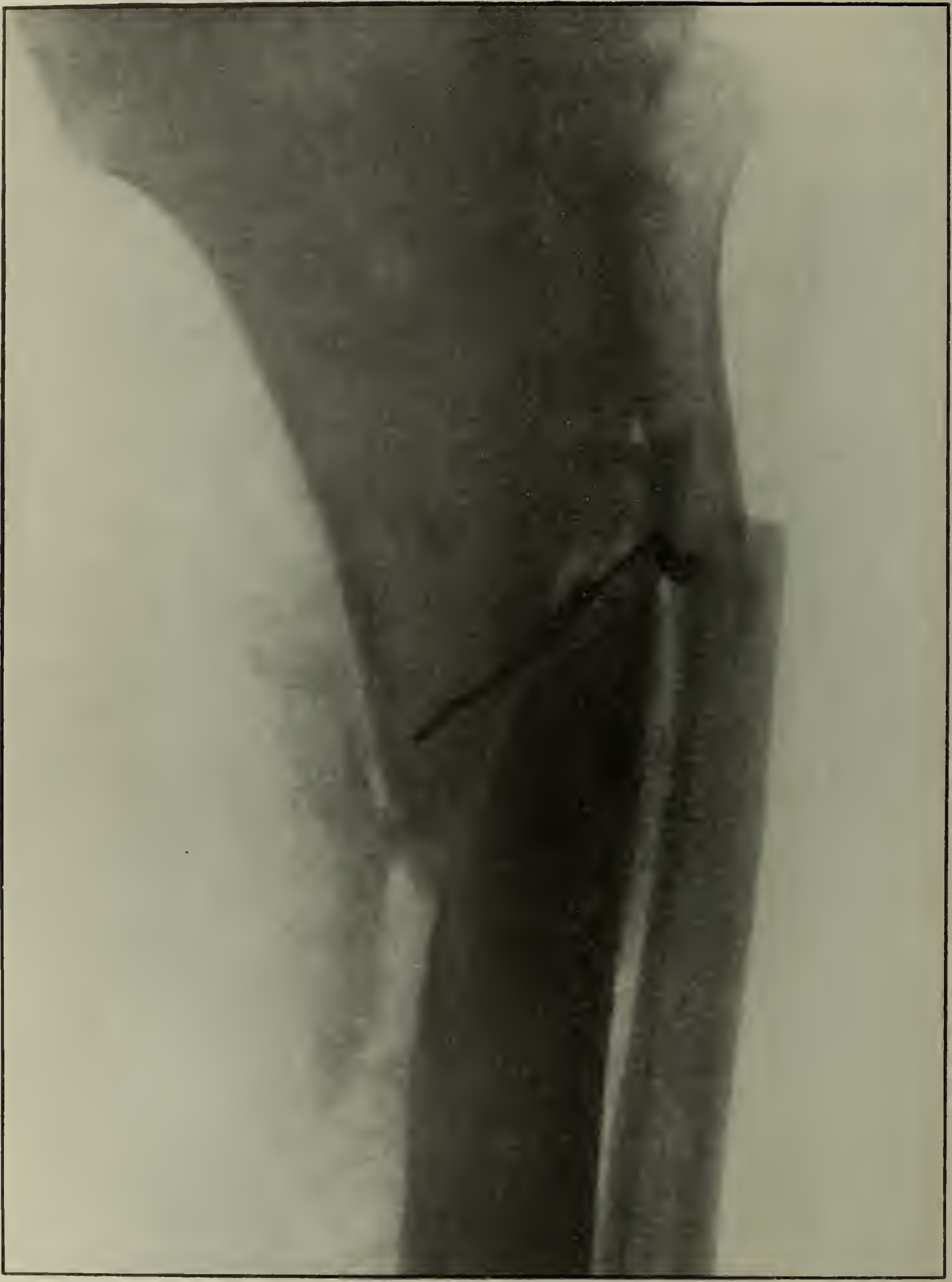


Operations—Plate 159.

Gunshot Fracture of the Radius and Ulna.

This plate shows an attempt to wire the radius and ulna where the indications were rather doubtful.

Plate 160.

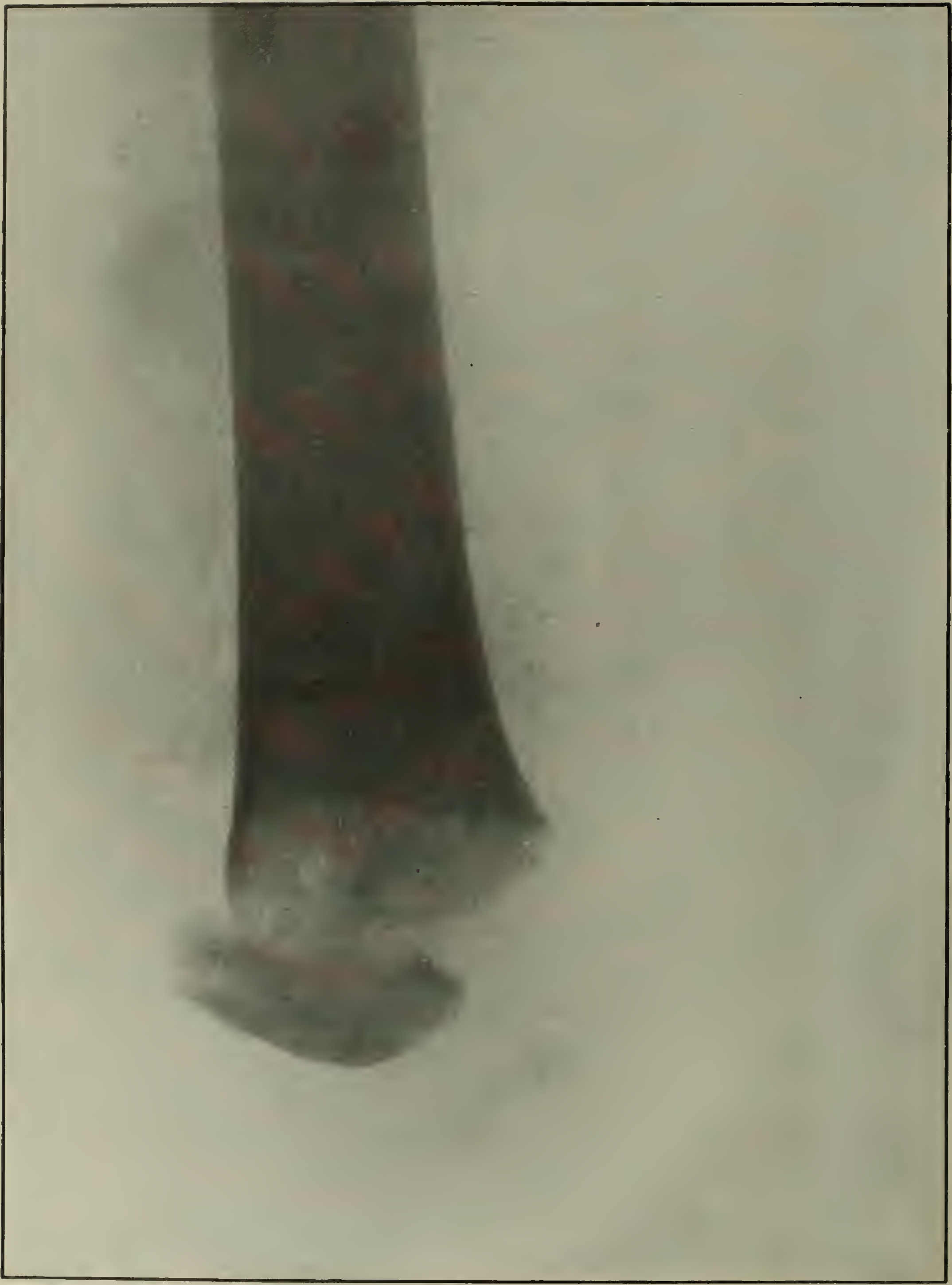


OPERATIONS—PLATE 160.

Gunshot Fracture of the Tibia and Fibula.

This plate shows an attempt at immediate immobilization of the fragments of the tibia which has failed to meet the mechanical indications for maintaining correct position.

Plate 161.

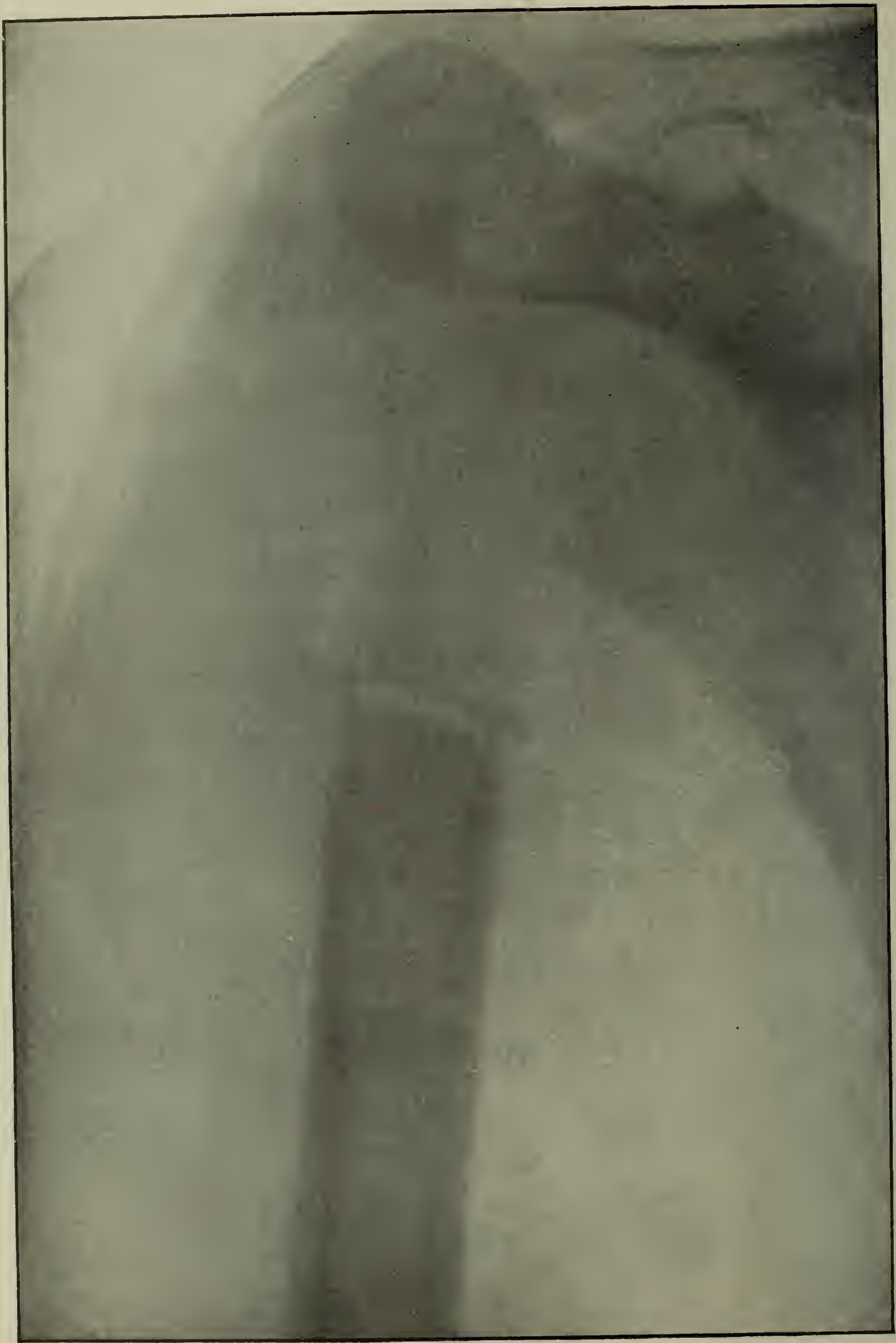


OPERATIONS—PLATE 161.

Amputation at the Knee Joint.

This plate shows a satisfactory result of a secondary amputation at the knee, after the method of Gritti, following a severe naval shell wound of the leg.

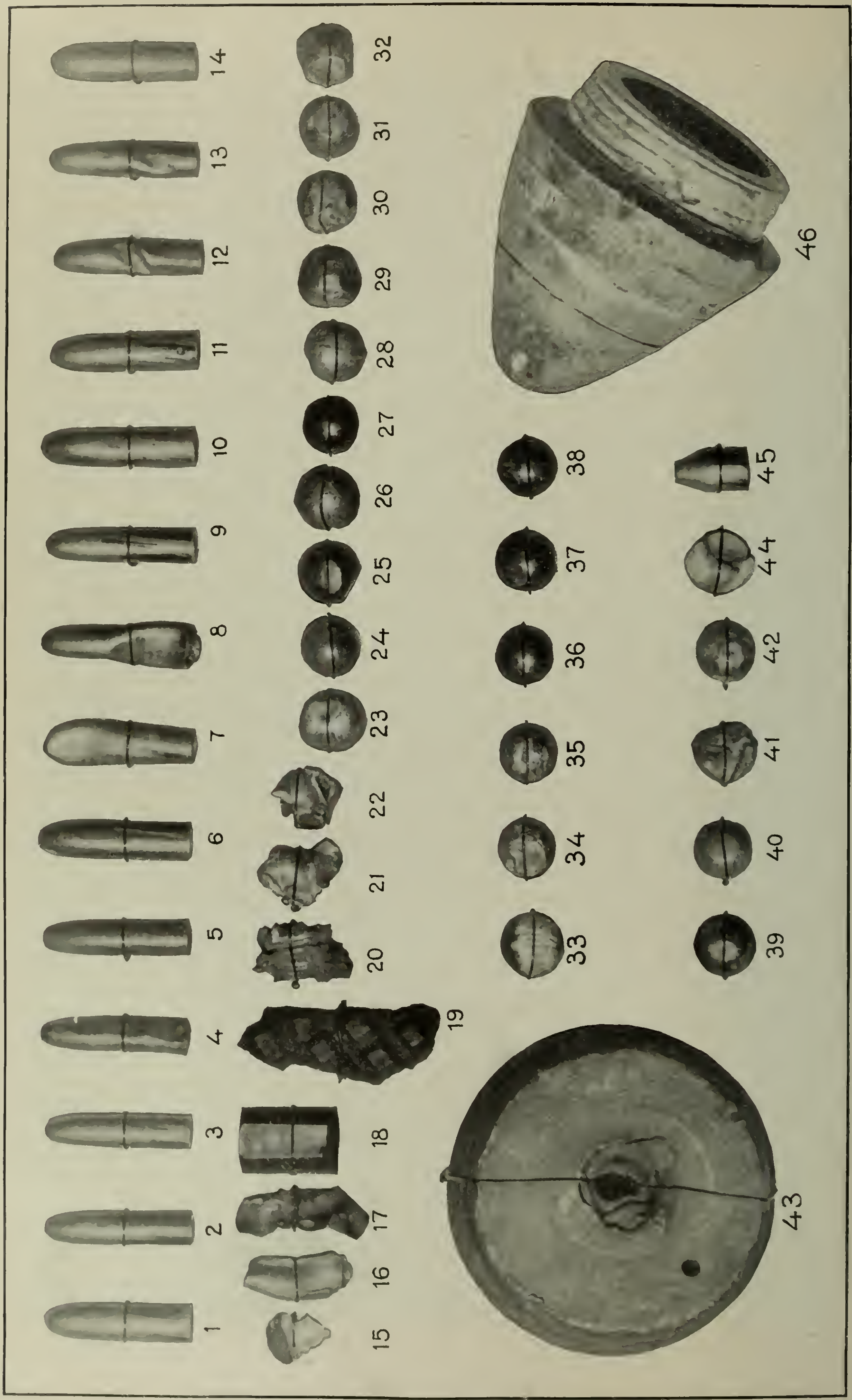
Plate 162.



OPERATIONS—PLATE 162.

Excision of the Head of the Humerus.

This plate shows a case of Prof. De Page, of the Belgium Red Cross Mission at Tash Kishla Hospital, in which the head of the humerus was excised for extensive comminution of the head of the humerus with infection.



SOME MISSILES REMOVED FROM WOUNDED IN BALKAN WARS.

Figures reduced to two-thirds of natural size.

PLATE 163.

Of the 46 missiles shown in the illustration, page 336, 1 to 14 are rifle bullets; 15 to 22 are assorted fragments; 23 to 43 and including 44 are shrapnel balls; 45 is an automatic pistol ball, and 43 and 46 are the base and the fuse, respectively, of a shrapnel "nose" or head of the 75-millimeter field gun.

Four rifle bullets, three shrapnel balls, and Nos. 20 and 27 were removed from Turkish soldiers admitted to my service at Tash Kishla Hospital in Constantinople. The remaining missiles, excepting No. 46, were removed from Bulgarian soldiers on my service at the Etap and the Queen's Hospital at Kustendil, Bulgaria. The missile shown as No. 46 was removed by Dr. Tatarcheff, the Bulgarian surgeon in command of a fixed hospital at Kodemos, Bulgaria, from the upper anterior thigh of a patient whose history I have and whom I saw and photographed.

Of the fragments, Nos. 15 and 17 are pieces of the nickel jacket of rifle bullets; No. 16 is the lead "core" of a rifle bullet; No. 22 is a fragment of the nickel jacket of a rifle bullet which holds a small portion of the lead core; No. 18 is a brass tube which is carried in the base of a shell to hold the detonating plunger and fulminate cap; No. 19 is a piece of a foot plate or step of a gun carriage or caisson; No. 20 is a shell fragment, and No. 21 is a flattened piece of a shrapnel ball.

Of the bullets, No. 1 is Bulgarian, removed from a Bulgarian soldier in an operation for an abdominal wound accidently inflicted during the firing incident to the celebration attending the announcement of peace; Nos. 6, 10, 11, and 14 are of the same caliber as the Bulgarian and were fired from Montenegrin or Servian rifles; Nos. 2 and 3, slightly smaller in caliber than all the others, are Greek, and Nos. 4, 5, 7, 8, 9, 12, and 13 are Servian, slightly larger than the Greek and as much smalled than the Bulgarian. No. 1 is abraided at the base by the jaws of a forceps by which it was removed from the wing of the ilium in which it was firmly embedded; Nos. 4, 7, 8, 12, 13, 14 are deformed by ricochet. No. 5 has its nose slightly abraided by the same cause. No. 8 shows the lead core protruding from the base of the jacket. Nos. 1, 2, 3, 6, 9, 10, and 11 are normal, as they struck the body by direct impact. Nos. 2 and 3, which are Greek, have the nickel jacket worn off on the apex so that the lead core is exposed, which produces a slight degree of "dum-dum," but as they struck the body at very long range and without hitting a bone, they produced no "dum-dum" effect.

Eight of the shrapnel balls were removed from the forearm of one Bulgarian soldier. (Vide plate 109.)

No. 43 was removed from between the thoracic wall and the scapula, to which position it passed by destroying the outer half of the clavicle, penetrating 6 inches from the surface.

The caliber of the missiles.

	Millimeters.
Greek	6. 50
Servian	7. 00
Bulgarian	8. 00
Montenegrin	7. 65 and 8. 00

For comparison it may be observed that the United States Army rifle bullet is 7 millimeters, equal 30 caliber or 0.30 inch.

The caliber of shrapnel balls varies somewhat, as do the weight and density, but all of them were approximately ½ inch or 125 millimeters in diameter.

The caliber of all field guns (of modern type) in the Balkan wars were 75 millimeters, the "soixante-quinze" of the French, or about 3 inches.

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